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Biological Assessment of Artificial Propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of chinook salmon and steelhead trout

Prepared by

U. S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
Red Bluff, CA 96080

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2002-005867/NF

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Document Overview

Purpose of the Document: This Biological Assessment (BA) is required to fulfill the U.S. fish and Wildlife Service's (Service) obligations for consultation under section 7(2)(a) of the federal Endangered Species Act of 1973 (ESA) with the National Marine Fisheries Service (NMFS). This document is intended to provide a single, comprehensive source of information to describe and assess impacts of current or proposed operations of the Coleman and Livingston Stone National Fish Hatcheries (NFH's) on ESA-listed Central Valley populations of anadromous salmonids. The ESA Section 7(2)(a) consultation process is specifically designed to determine if proposed activities are or are not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of their critical habitats. In addition to fulfilling this customary role as part of the ESA Section 7 consultation process, this BA also focuses on potential impacts of hatchery facilities and operations within the Battle Creek watershed, and addresses many of the concerns raised during the Coleman NFH Re-evaluation Process. The Service recognizes the importance of integrating hatchery operations with natural salmonid production in Battle Creek, especially in light of pending restoration activities within the watershed.

Within this assessment, the Service acknowledges that incidental take[1] of ESA-listed species of anadromous salmonids may occur during the course of conducting fish propagation programs described in this document. In some cases incidental take estimates are directly quantifiable while in many other cases, impacts can only be assessed qualitatively. Based on our assessment, the Service believes that operations of Coleman and Livingston Stone NFH's are not likely to jeopardize the continued existence of listed (or candidate) Central Valley populations of anadromous salmonids. As a result of the submission of this BA, the Service is expectant that the NMFS will issue a Biological Opinion and incidental take authorization to cover the incidental take of all ESA-listed Central Valley salmonids impacted by the described artificial propagation activities.

Format of Biological Assessment: The format of this BA follows the highly-detailed format of the Hatchery and Genetic Management Plan (HGMP) developed by NMFS. The HGMP template is intended to provide a single source of hatchery information for comprehensive planning purposes, and to satisfy permitting requirements under the ESA. The document is divided into14 Sections. A brief description of each section is presented below.

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[1] "Take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

Section 1: *General Program Description*

Section 1 provides a broad overview of Coleman and Livingston Stone NFH programs and operations including: 1) facility locations, 2) types and sizes of artificial propagation programs conducted at each facility, 3) purpose and justification for the propagation programs, 4) performance standards and indicators developed to assess program benefits and risks, and 5) some measures of current program performance including estimated smolt-to-adult survival rates, fishery (i.e., harvest) contribution rates, and hatchery return rates.

Section 1 is not intended to stand alone; rather, it provides an introduction and overview of several aspects of the hatchery propagation programs that are more thoroughly discussed in other sections of the document. Likewise, the"bulleted" statements accompanying descriptions of Performance Standards and Performance Indicators (Sections 1.9 and 1.10) are also not meant to stand alone. In the format they are presented they do not defend a hatchery benefit, nor do they refute or concur with a potential risk of hatchery activities. As with the majority of the information presented in Section 1, they are intended to provide the basis for discussions which follow in subsequent sections of the document. It is recommended that the reader review the table of contents, including the list of appendices (Section 13), for other sections that provide detailed descriptions of specific topic areas.

Section 2: *Program Effects on Salmonid Populations*

Section 2 provides description, status, and listing history of Central Valley anadromous salmonid populations potentially impacted (directly or indirectly) by activities associated with the artificial production programs conducted at Coleman and Livingston Stone NFH's. This section also briefly describes the original legislation authorizing the Central Valley Project (CVP) and the mitigation or "Salvage Plan" for the CVP which included the construction of the Coleman NFH. The history of ESA permits held by the Service to conduct artificial propagation activities at Coleman and Livingston Stone NFHs is also discussed in this section. Lastly, Section 2 provides a summary of potential impacts on ESA-listed populations of salmonids resulting from hatchery facilities and proposed activities. Whenever possible, quantified estimates of take have been generated (Section 2.11.1), however, for many activities only a qualitative assessment of impact was possible (Section 2.11.2). Because Sections 2.11.1 and 2.11.2 are intended to only summarize estimates of take, subsequent Sections of this document and appendices should be referenced for the actual derivation of take estimates or the information supporting the qualitative impact assessments.

Section 3: *Relationship to Other Management Objectives*

In Section 3 we describe the relationship between artificial propagation programs at Coleman and Livingston Stone NFH's and other fishery and habitat management objectives and conservation programs in the Central Valley of California. Current and proposed hatchery operations are discussed in relation to major conservation programs designed to restore and recover anadromous salmonids and their habitats in the Central Valley, including: the Central Valley Project

Improvement Act (CVPIA) and associated Anadromous Fish Restoration Program (AFRP), and the CALFED Ecosystem Restoration Program (ERP). In this section we also describe the Coleman NFH Re-evaluation Process with its objectives to assess and refine hatchery facilities and operations, and the relationship between Coleman NFH and the Battle Creek Restoration process. We discuss the roles of the U.S. Bureau of Reclamation (primary funding source) and the U.S. Fish and Wildlife Service (operational responsibilities) relative to responsibilities to mitigate for habitat losses due to the Construction of Shasta Dam. Lastly, in Section 3 we describe harvest objectives for Coleman NFH, and identify contribution rates of the chinook salmon propagation programs to the ocean (commercial and sport) and the in-river sport fisheries. Furthermore, because harvest of fish from Coleman NFH and adult escapement to Battle Creek are closely linked, a discussion is presented on historical and recent adult escapement as a result of hatchery operations, and the potential impact of escapement or over-escapement of hatchery-origin adults back to the Battle Creek watershed.

Section 4: *Hatchery Water Source*

Section 4 provides a description of current hatchery water rights and water usage patterns, and hatchery intake structures and water delivery systems for Coleman and Livingston Stone NFHs. Estimates of take of ESA-listed and non-listed salmonids in association with hatchery water diversions are presented. Also discussed in Section 4 are: 1) potential impacts of water discharges from the hatchery facilities; 2) potential impacts to instream flow associated with hatchery water diversions, including emergency hatchery water-supply situations; and, 3) the potential for instream flow impacts during times of extremely low water or drought years.

Recognizing that take of ESA-listed species associated with the current water intake structures is inconsistent with Battle Creek the Service's goal of integrating hatchery activities with Battle Creek restoration, a process is in place to evaluate alternatives to modify the Coleman NFH water delivery system (e.g., screen the intakes). A discussion of the status of the intake design process is also included in this section.

Section 5: *Facilities*

Section 5 provides a description of physical facilities at Coleman and Livingston Stone NFH's, including: schematics of the property and a description of all physical structures at each facility. An assessment of the potential impacts of facility maintenance and on-site construction on critical habitat is provided in this section.

Section 6: *Broodstock Origin and Identity*

Section 6 presents information regarding the source of broodstock used at Coleman and Livingston Stone NFH's, the history of their use, and the numbers of broodstock proposed to be used annually. Phenotypic and genetic differences between hatchery broodstock and natural adults are discussed. Also discussed in Section 6 are past and proposed levels of incorporating naturally-produced adults as hatchery broodstock. Lastly, a discussion is presented of risk aversion measures that are being used to minimize the likelihood of negative impacts on naturally produced salmonids.

Section 7: *Broodstock Collection*

In Section 7 we discuss aspects of broodstock congregation and collection, including descriptions of: collection locations (Coleman NFH barrier weir, Keswick Dam fish trap, and Red Bluff Diversion Dam fish trap); collection timing; and, stocks and numbers targeted. Also discussed are methods to identify runs (phenotypic and genetic criteria) and methods to differentiate hatchery and natural stocks (i.e, mark identification).

Because of the importance of the Coleman barrier weir in regards to collecting hatchery broodstock and managing and monitoring passage of salmonids into upper Battle Creek, a large portion of Section 7 is dedicated to the hatchery barrier weir. Estimates are generated for: 1) unintentional escapement above the weir, and 2) take of ESA-listed adult salmonids resulting from delay, blockage, or diversion at the barrier weir.

Section 8: *Mating*

In Section 8 we discuss broodstock selection methodologies, spawn timing and spawning schedules, and mating protocols. Also included in Section 8 are discussions of proposed changes to current spawning practices at Coleman NFH.

Section 9: *Incubation and Rearing*

Section 9 provides information on current and anticipated incubation and rearing practices at Coleman and Livingston NFH's. Specific data provided include: 1) survival rates over various life stages for all species propagated, 2) density indices, final densities and final fork lengths by species propagated and by rearing unit type; and, 3) feed types and expected conversion rates. A general discussion of an experimental NATURE'S rearing pond currently used at Coleman NFH concludes Section 9.

Section 10: *Juvenile Releases*

Section 10 provides a description of juvenile release practices, including marking and tagging rates, release location and timing, and size at release for all species propagated at Coleman and Livingston Stone NFH's. The section also provides comprehensive assessment of impacts resulting from hatchery releases (i.e., predation, competition, displacement, disease transmission) to all stocks of naturally-produced anadromous salmonids.

Section 11: ***Monitoring and evaluation***

We provide in Section 11 a general description of the Hatchery Evaluation Program coordinated out of the Red Bluff Fish and Wildlife Office. Also presented is a discussion of monitoring activities associated with evaluating hatchery performance, and assessing impacts to natural salmonid populations. Data collected during monitoring efforts are used to adaptively manage hatchery programs in order to maximize hatchery benefits and minimize hatchery risks.

Section 12: ***Research***

Section 12 provides information on current research activities conducted in direct association with the hatchery propagation programs.

Section 13: ***Citations, Appendices, and Attachments***

Section 13 provides the list of literature referenced in this document. Also contained in Section 13 are several appendices that include information and analyses that are critical understanding the impact assessments found within this document, including:

- Genetics and Hatchery Programs
- False Attraction (Decoying)
- Analysis of Stray Rates
- Generation of Harvest Estimates
- Fry vs. Smolt contribution analysis
- Analysis of Over-Escapement
- Predictive Model to Estimate Future Harvest, Escapement, and Return to the Hatchery
- Compilation of previous Releases from CNFH

Section 14: ***Certification language and signatures***

Section 14 contains signatures of appropriate officials to certify the primary purpose of the Biological Assessment is to obtain limits from take prohibitions under the Endangered Species Act of 1973.

Section 15: ***Response to Comments***

Section 15 presents written comments on the draft Biological Assessment submitted by various public and private agencies and citizens. Brief responses to these comments are also presented, with references to changes and relevant sections of the document where appropriate.

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LIST OF ABBREVIATIONS

Anadromous Fish Restoration Program	AFRP
Anderson-Cottonwood Irrigation District	ACID
Bacterial kidney disease	BKD
Battle Creek Working Group	BCWG
Biological Assessment	BA
Biological Opinion	BO
Bodega Marine Laboratory	BML
Bonneville Power Administration	BPA
CALFED Ecosystem Restoration Plan	ERP
California Endangered Species Act	CESA
California Department of Fish and Game	CDFG
California Department of Water Resources	DWR
California-Nevada Fish Health Center	CA-NV FHC
California Regional Water Quality Control Board	WQCB
Carbon dioxide	CO_2
Central Valley Project	CVP
Central Valley Project Improvement Act	CVPIA
Coded-wire tag	CWT
Effective population size	N_e
Federal Endangered Species Act	ESA
Evolutionarily Significant Unit	ESU
Fall chinook salmon	FCS
Federal Register	FR
Fork length	FL
Glen-Colusa Irrigation District	GCID
Hatchery and Genetic Management Plan	HGMP
Infectious Hematopoietic Necrosis virus	IHNV
Late-fall chinook salmon	LFCS
Memorandum of Understanding	MOU
National Environmental Policy Act	NEPA
National Fish Hatchery	NFH
National Marine Fisheries Service	NMFS
National Pollution Discharge Elimination System	NPDES
Natural Rearing Enhancement System	NATURES
Pacific Fishery Management Council	PFMC
Pacific Gas and Electric	PG&E
Pacific Salmon Commission	PSC
Pacific States Marine Fisheries Commission	PSMFC
Red Bluff Diversion Dam	RBDD

Red Bluff Fish and Wildlife Office	RBFWO
River mile	RM
Steelhead trout	STT
United States Bureau of Reclamation	USBR
United States Fish and Wildlife Service	Service
Young-of-year	YOY
Winter chinook salmon	WCS

GENERAL PROGRAM DESCRIPTION

1.1 Name of hatchery

Coleman National Fish Hatchery (NFH), Anderson, California and Livingston Stone NFH, Shasta Dam, California. Both facilities are operated by the United States Fish and Wildlife Service (Service).

1.2 Species and population(s) under propagation, and ESA/CESA status of associated salmonids

The Coleman NFH and its substation at Shasta Dam, the Livingston Stone NFH, propagate three runs of chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *Oncorhynchus mykiss*. Fall and late-fall chinook salmon and steelhead trout are propagated at Coleman NFH. Winter chinook salmon are propagated at the Livingston Stone NFH. Winter chinook adults for the captive broodstock program are held at Livingston Stone NFH and two long-term rearing facilities: Steinhart Aquarium and Bodega Marine Laboratory (BML).

The hatchery stock of winter chinook is listed as endangered under the federal Endangered Species Act (ESA) (Table 1-1). Currently, this is the only stock propagated at Coleman or Livingston Stone NFH's that is listed under the ESA; however, all stocks of salmonids reared at Coleman and Livingston Stone NFH's are considered part of the Central Valley Evolutionarily Significant Units (ESU) for their respective species.

Spring chinook salmon were also propagated at Coleman NFH between 1943 and 1951 (except for 1948). Efforts to propagate spring chinook salmon were not successful for a variety of reasons including high water temperatures during broodstock collection and low numbers of available broodstock (Luken et al. 1981). Consequently, propagation of spring chinook salmon was terminated after brood year 1951. The feasibility of restoring the spring chinook propagation program is currently under investigation through the Coleman NFH Re-evaluation Process (report to be submitted to the Service by Harza, Inc. by September 30, 2001). For additional information on past efforts to propagate spring chinook salmon at Coleman NFH see Appendices 1A (history), 6A (broodstock spawning), and 10A (juvenile releases).

The natural population of winter chinook in the Sacramento River is also listed as endangered under the ESA, and natural populations of Central Valley steelhead trout and spring chinook salmon are listed as threatened under the ESA (Table 1-1). Fall and late-fall chinook salmon in the Central Valley of California are not currently listed under the ESA, but they are considered candidate species. Under the California Endangered Species Act (CESA), the natural population of winter chinook salmon is listed as endangered, and natural spring chinook salmon are listed as threatened.

Table 1-1. Federal Endangered Species Act (ESA) and California Endangered Species Act (CESA) status of natural and hatchery populations of chinook salmon and steelhead in the Central Valley, California. An indication whether they are considered part of the Evolutionarily Significant Unit (ESU) of the species is also presented.

Species ***Scientific name***	**Hatchery**	**ESA status of natural stock**	**ESA status of hatchery stock**	**CESA status of natural stock**
Fall Chinook Salmon *Onchorynchus tshawytscha*	Coleman	Candidate	Part of the ESU/ Not listed	Not Listed
Late-fall chinook salmon *Onchorynchus tshawytscha*	Coleman	Candidate	Part of the ESU/ Not listed	Species of Concern
Steelhead *Onchorynchus mykiss*	Coleman	Threatened	Part of the ESU/ Not listed	Not Listed
Winter chinook salmon *Onchorynchus tshawytscha*	Livingston Stone	Endangered	Part of the ESU / Endangered	Endangered
Spring chinook salmon *Onchorynchus tshawytscha*	Not Propagated	Threatened	Not Propagated	Threatened

1.3 Responsible organization and individuals

Primary Contact

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Hatchery Evaluation and Permitting Contact

Mr. James G. Smith, Project Leader
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Northern Central Valley Fish and Wildlife Office
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Red Bluff, CA 96080
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FAX: (530) 529 - 0292
e-mail: jim_smith@fws.gov

Additional responsible agencies:
Coleman NFH and Livingston Stone NFH are mitigation features necessary to offset habitat lost due to the construction of Shasta Dam, part of the Central Valley Project (CVP). Although the facilities are operated by the Service, funding for the facilities remains the responsibility of the U.S. Bureau of Reclamation (USBR).

Contact: Mr. Mike Ryan, Area Manager
U.S. Bureau of Reclamation
Shasta Lake, California 96019
(530) 275-1554

Two long-term, off-site, rearing facilities for the winter chinook salmon captive broodstock program are BML and Steinhart Aquarium.

Contact: Dr. Kristin Arkush
Bodega Marine Laboratory
University of California at Davis
2099 Westside Road
Bodega Bay, CA 94923
Tel: (707) 875 - 2062
Fax: (707) 875 - 2089

1.4 Funding source, staffing level, and annual hatchery program operational costs

The USBR provides the Service an annual budget of approximately $3 million for operating the Coleman NFH and various support services. Funding for the operation of Livingston Stone NFH has yet to be provided by the USBR and is currently coming directly from existing operation and maintenance funds for Coleman NFH. Additional funding may also be secured from other funding sources (e.g., CVPIA, AFRP) for construction, facility rehabilitation or other project requirements. Total staff for both Coleman NFH and Livingston Stone NFH currently is approximately 25 permanent employees and five to fifteen temporary employees and volunteers.

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1.5 Locations of hatcheries and associated facilities

Coleman and Livingston Stone NFH's are located in the upper Sacramento River basin in the Central Valley of northern California (Figure 1-1). Coleman NFH is located on the north bank of Battle Creek, a tributary to the Sacramento River, approximately three miles east of the Sacramento River and twenty miles southeast of the city of Redding. Livingston Stone NFH is located on the west side of the Sacramento River, approximately 0.5 miles below the base of Shasta Dam (Keswick Reservoir). The regional mark processing center codes for Coleman NFH and Livingston Stone NFH recognized by the Pacific Salmon Commission are 6FCSASAF CNFH and 6FCSASAF LVNH, respectively.

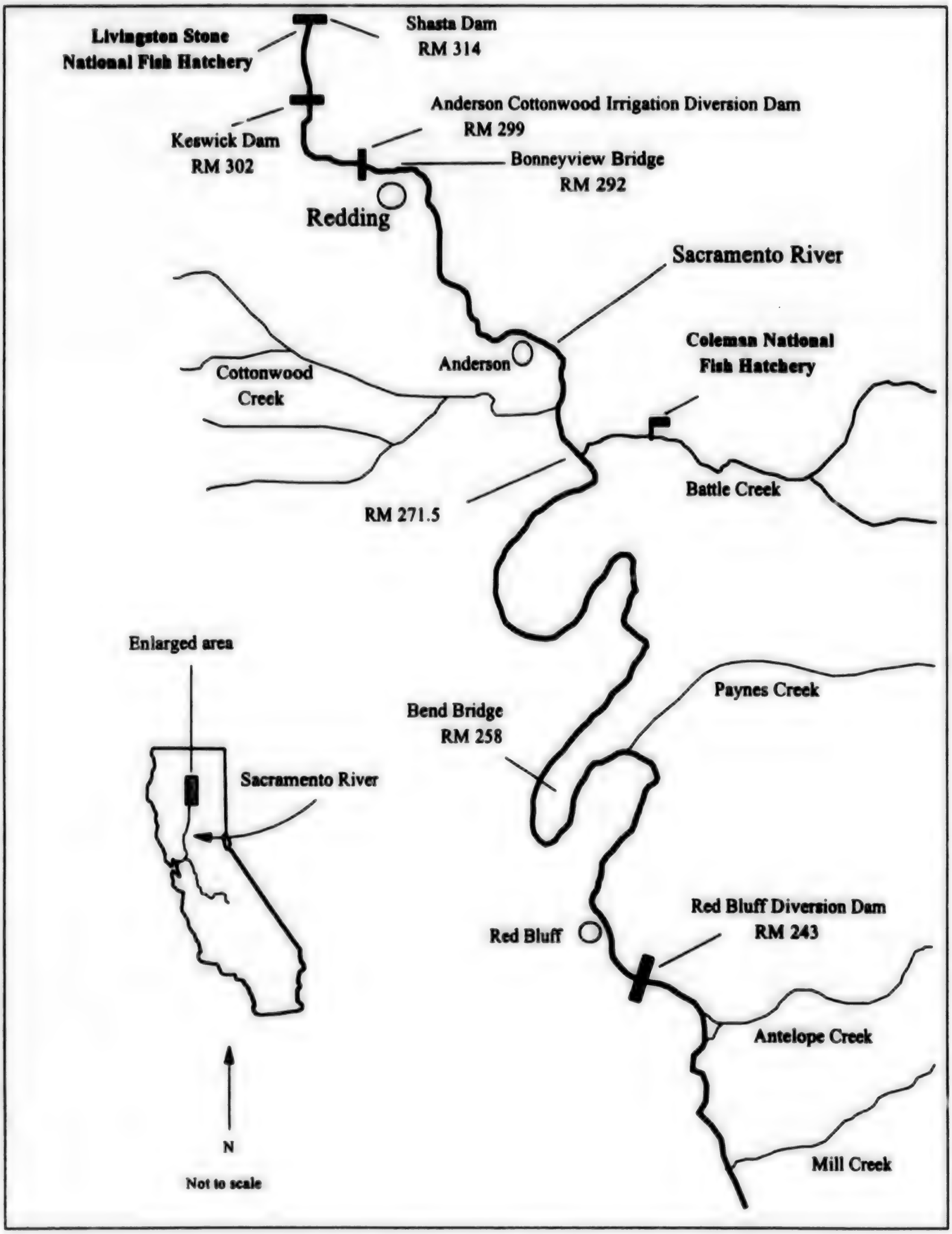

Figure 1-1. Locations of Coleman and Livingston Stone National Fish Hatcheries and major landmarks in the upper Sacramento River, California.

1.6 Type of programs

Propagation of winter chinook salmon is exclusively conducted at Livingston Stone NFH. Propagation programs conducted at Coleman NFH include: fall and late-fall chinook salmon and steelhead trout.

Fall Chinook Salmon

Coleman NFH's fall chinook salmon propagation program is an *integrated-harvest* type program. The primary goal of Coleman NFH's fall chinook salmon program is mitigation, primarily for the purpose of contributing to *harvest* in the Sacramento River sport fishery and sport and commercial ocean fisheries. Coleman NFH's fall chinook salmon propagation program is considered to be integrated with naturally spawning fall chinook salmon in the upper Sacramento River and Battle Creek for the following reasons: 1) founding broodstock for fall chinook salmon at Coleman NFH were endemic fall chinook salmon from Battle Creek and the upper Sacramento River; 2) hatchery- and natural-origin fall chinook share a long and continuous history of integration through spawning at Coleman NFH and natural spawning in Battle Creek and the upper Sacramento River; and, 3) hatchery fall chinook salmon are considered to be substantially similar to natural-origin fall chinook salmon in regards to morphology, behavior, genetics, and life history characteristics.

Late-fall Chinook Salmon

Coleman NFH's late-fall chinook salmon propagation program is an *integrated-harvest* type program. The goal of Coleman NFH's late-fall chinook salmon program is mitigation, primarily for the purpose of contributing to *harvest* in the Sacramento River sport fishery and ocean sport and commercial fisheries. Late-fall chinook salmon at Coleman NFH are considered to be *integrated* with the natural population in the upper Sacramento River because: 1) they share similar ancestry with upper Sacramento River late-fall chinook; 2) natural-origin adults have been regularly incorporated as hatchery broodstock; 3) hatchery-origin adults stray and spawn naturally with natural-origin late-fall chinook, primarily in the upper Sacramento River; and, 4) hatchery late-fall chinook salmon are considered to be substantially similar to natural-origin late-fall chinook salmon in regards to morphology, behavior, genetics, and life history characteristics.

Winter Chinook Salmon

The Service's artificial propagation program for winter chinook salmon at Livingston Stone NFH and captive broodstock programs at Livingston Stone NFH, BML, and Steinhart Aquarium are characterized as *integrated-recovery* type programs. That is, hatchery propagated winter chinook salmon are managed to be *integrated* with the natural population of winter chinook salmon in the upper Sacramento River, and are intended to aid in the *recovery* of that population. Hatchery-origin winter chinook salmon are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural population. The goal of the winter chinook salmon captive broodstock program is to provide short-term security against extinction for the at-risk population while environmental factors leading to their decline are corrected. In addition to providing a secure population to avert extinction, captively-reared winter chinook salmon may be used for mating, and their progeny may be released into the Sacramento River to integrate with the naturally spawning population.

Steelhead Trout
The steelhead trout propagation program at Coleman NFH is currently in transition from an *integrated-harvest* type program to an *integrated* program with the goal of assisting in the *recovery* of natural steelhead trout in the upper Sacramento River system. Since the beginning of the Coleman NFH steelhead program in 1947, the primary goal has been to contribute to sportfishing harvest in the Sacramento River. In 1998, the National Marine Fisheries Service (NMFS) listed steelhead trout in California's Central Valley ESU as threatened under the ESA because of a long-term trend of declining abundance. Coleman NFH steelhead trout were included as part of the Central Valley steelhead ESU (Busby et al 1996) based largely on genetic similarity with naturally-produced steelhead trout in the Sacramento River system. In light of the long-term trend of population declines for naturally produced steelhead trout and a robust steelhead trout propagation program at Coleman NFH, the Service has re-evaluated the goals of the Coleman NFH steelhead trout. Since 1995, hatchery-origin steelhead trout from Coleman NFH have been used in attempts to re-establish a naturally spawning population in Battle Creek. The Service will investigate the potential utility of hatchery-origin steelhead for recovery of steelhead populations in other areas of the upper Sacramento River system.

1.7 Purpose (Goal) of programs

Fall and Late-fall Chinook Salmon
Construction and operation of Shasta Dam resulted in the loss of approximately 187 miles of spawning and rearing habitat for salmonids. The Service produces fall and late-fall chinook salmon at Coleman NFH to *mitigate* for this loss of habitat and the consequent reduction in salmonid populations. Fall and late-fall chinook salmon are produced by these programs primarily to contribute to harvest in the ocean commercial fishery, ocean sport fishery, and freshwater sport fishery. Another goal of these programs is to provide adequate escapement back to the hatchery for broodstock purposes. The Service intends to achieve these goals while minimizing negative effects on natural populations. Because fall and late-fall chinook salmon at Coleman NFH are integrated with the natural spawning populations in Battle Creek and the Sacramento River, these hatchery stocks may also be appropriate for future recovery efforts if needed.

Winter Chinook Salmon
The Service's propagation program for winter chinook salmon consists of two separate elements, artificial production and captive broodstock. The primary goal of the Service's artificial production program at Livingston Stone NFH is to assist in the *restoration* and *recovery* of the indigenous winter chinook salmon population in the upper Sacramento River. The primary goals of the captive broodstock program are *preservation/conservation* and research of the genetic resources of the Sacramento River winter chinook salmon population. The captive broodstock program for winter chinook salmon is a cooperative effort between the Service, BML, and Steinhart Aquarium.

Steelhead Trout

Since the Coleman NFH steelhead trout program was founded in 1947, the primary goal of the program has been *mitigation* for habitat losses resulting from the CVP. The steelhead trout propagation program at Coleman NFH mitigates for the loss of more than 187 miles of steelhead trout spawning and rearing habitat caused by the construction of Shasta Dam. Steelhead trout propagated at Coleman NFH are intended to contribute primarily to the sport fishery in the Sacramento River and delta. Another goal of this program is to provide adequate escapement back to the hatchery for broodstock purposes. The Service attempts to achieve these goals while minimizing risks to natural populations of salmonids.

As a result of the recent ESA listing of Central Valley steelhead trout and a robust hatchery propagation program for steelhead trout at Coleman NFH, the Service has re-evaluated the goal of the Coleman NFH steelhead trout program. An additional goal of this program will be to assist in the recovery of naturally producing steelhead trout populations, particularly in Battle Creek. The purpose of using artificial propagation for the recovery of steelhead trout is to facilitate rapid restoration of natural populations and minimize the risk of further decline. Concurrent with the habitat restoration program in Battle Creek, initial focus has been on restoring a naturally reproducing steelhead trout population in that tributary. The Service will investigate the potential of using hatchery-origin steelhead trout for recovering natural populations in other areas of the upper Sacramento River system. Steelhead trout at Coleman NFH may also be considered a "population reserve" to preserve genetic resources for possible future recovery efforts.

Because of the continuous reproductive and genetic assimilation between Coleman NFH steelhead trout and natural populations of steelhead trout in the Sacramento River and Battle Creek, the hatchery stock of steelhead trout is appropriate to use for recovery efforts. The consistent integration of natural adults as broodstock at Coleman NFH has reduced the potential for appreciable divergence from natural populations. Coleman NFH's stock of steelhead trout was founded from, and has been systematically *integrated* with, naturally spawning steelhead trout from the upper Sacramento River and Battle Creek. By 1947 when the Coleman NFH steelhead trout program was initiated, naturally produced steelhead trout were at low abundance in Battle Creek resorted to the Keswick Dam fish trap for collection of founding broodstock. Natural-origin steelhead trout collected from the upper Sacramento River were regularly incorporated as hatchery broodstock for 21 brood years between 1947 and 1986. In addition, natural- and hatchery-origin steelhead trout from Battle Creek have been used as hatchery broodstock since 1952 when a hatchery run became established in that tributary.

Reproductive and genetic *integration* of Coleman NFH steelhead trout with natural spawning populations has also occurred through straying and natural spawning of hatchery-origin adults. An unknown (but presumably small) number of hatchery-origin steelhead trout adults stray and spawn naturally in the upper Sacramento River system. Hatchery-origin steelhead have been regularly passed above the Coleman barrier weir to spawn naturally in upper Battle Creek, so the existing run of steelhead trout in Battle Creek is of mixed hatchery- and natural-ancestry.

1.8 Justification for the program

Coleman National Fish Hatchery

The Sacramento River in northern California is the only river in the world which has four distinct runs of chinook salmon (fall, late fall, winter and spring) and steelhead trout. In 1942, the uppermost drainage was blocked by the construction of Shasta Dam, the keystone of the CVP. The construction of Shasta Dam resulted in the permanent blockage of approximately 50% of chinook salmon and steelhead trout spawning and rearing habitats (Skinner 1958). To mitigate for habitat lost upstream of Shasta Dam, the federal government established the Shasta Salvage Plan which contained several features including the construction and operation of a fish hatchery (Moffett 1949; see Black 1999 for a detailed accounting of the development of the Shasta Salvage Plan; also see Section 1.17 and Section 2.2 of this document for additional information on the original authorization of Coleman NFH). Coleman NFH was constructed on Battle Creek (a tributary of the Sacramento River) in 1942, and fish culture operations began in 1943. The hatchery currently propagates three salmonid stocks: fall chinook salmon, late-fall chinook salmon, and steelhead trout. Until recently, endangered winter chinook salmon were also reared at Coleman NFH (rearing of winter chinook salmon was transferred to Livingston Stone NFH when that facility was constructed in 1997).

Central Valley fishery resources contribute substantially to the region's social, cultural, and economic well-being. Coleman NFH is the principle remaining feature of the original Shasta Salvage Plan, and functions in a critical role by helping to mitigate the negative effects of construction of Shasta Dam on Central Valley salmon populations. Coleman NFH contributes substantially to the multi-million dollar commercial and recreational fishing industry in California (see Section 3.5, Relationship of program to harvest objectives). Additionally, prior to the construction of Livingston Stone NFH, Coleman NFH was an integral component of the recovery program for endangered winter chinook salmon, pioneering techniques for captive broodstock and supplementation programs.

Livingston Stone National Fish Hatchery

Livingston Stone NFH, a substation of Coleman NFH, was constructed by the USBR in late-1997 and is one of the newest hatcheries in the National Fish Hatchery System. The facility was constructed for the explicit purpose of propagating ESA-listed winter chinook salmon to assist in the recovery of that population. Currently, recovery efforts for winter chinook salmon involve two programs, the artificial propagation program and the captive broodstock program. Together, these programs are intended to prevent further loss of genetic variability and supplement reproduction of the naturally spawning population. Both programs are supported in the NMFS's draft Recovery Plan for winter chinook salmon (NMFS 1997).

Artificial Propagation Program

The Service initially attempted to propagate winter chinook salmon at Coleman NFH in 1955. This first attempt, as well as subsequent efforts from 1958 through 1967, was largely unsuccessful. From 1978 through 1985, several more attempts to propagate winter chinook salmon at Coleman NFH met with limited success. High water temperatures at Coleman NFH resulted in considerable mortality of adult broodstock, eggs, and juveniles.

In 1988, a Cooperative Agreement between NMFS, USBR, the Service, and California Department of Fish and Game (CDFG) outlined a 10-point plan to implement actions to improve the status of winter chinook salmon in the Sacramento River basin. Included in this plan was the [re-]development of an artificial propagation program at Coleman NFH, including necessary facilities and operations to meet hatchery production goals. Therefore, with the population of winter chinook in severe decline, the Service re-initiated a winter chinook salmon propagation program at Coleman NFH in 1989. The goal of the winter chinook hatchery propagation program at Coleman NFH was to supplement the natural spawning population in the Sacramento River.

By 1995, monitoring conducted by the Service's Hatchery Evaluation Program at Red Bluff demonstrated that rearing and release strategies intended to imprint hatchery-origin winter chinook juveniles to the mainstem Sacramento River were ineffective. A considerable portion of hatchery-propagated winter chinook adults were returning to Battle Creek and not assimilating with the natural population in the Sacramento River. This situation, as well as concerns of possible hybridization with spring chinook in the propagation program, resulted in a Service-imposed moratorium on the capture of natural winter chinook for Coleman NFH broodstock for two years (1996-1997). During these years, adults from the captive broodstock program (see below) were spawned and small numbers of juveniles were released.

Construction of the Livingston Stone NFH in 1997 and refined genetic methods for broodstock selection ameliorated concerns of homing and hybridization that led to the moratorium, so adult collections were re-initiated in 1998. The newly-constructed hatchery contains facilities for broodstock holding, spawning, and rearing. Juvenile winter chinook salmon were first released from this facility in April 1998.

Captive Broodstock Program

With natural winter chinook populations in imminent danger of extinction (total run estimate of 191 in 1991), the winter chinook captive broodstock program was developed in 1991 to guard against the potential extinction of the species until environmental conditions in the Sacramento River improve. For the captive broodstock program, a small number of juveniles (300-1,200) from each brood year of the winter chinook propagation program are reared to maturity at the Livingston Stone NFH, BML (University of California, Davis), or Steinhart Aquarium. The main goal of the winter chinook salmon captive broodstock program is to assure a source of gametes for the winter chinook propagation program if natural returns are too low to provide adequate numbers of adults as broodstock. Benefits of the captive broodstock program include:

1) a source of gametes (and thus juveniles) for the winter chinook propagation program, intended to supplement the naturally spawning population;
2) an egg and fry source for experimental and research purposes; and,
3) a potential tool to assist in the recovery of the species.

During the 1996-1997 moratorium on capture of natural winter chinook adults, winter chinook from the captive broodstock program were spawned. Juveniles from these matings were raised at Coleman NFH (1996 and 1997) and Livingston Stone NFH (1997) before release.

1.9 List of program performance standards

The following performance standards have been designed to evaluate the benefits and risks of fish propagation at Coleman NFH and Livingston Stone NFH. Performance standards have been classified as either "benefits" or "risks." Performance standards categorized as "benefits" measure the benefits resulting from the artificial propagation program (e.g., contribution to harvest, restoration, conservation/preservation, and/or research). Performance standards categorized as "risks" measure the possible risks the artificial propagation program may pose to natural populations. Performance standards designed to assess benefits (B) are listed first, with performance standards designed to assess risks (R) following. The following abbreviations are used to indicate the specific propagation programs at Coleman NFH and Livingston Stone NFH to which the performance standard applies: FCS - fall chinook salmon; LFCS - late-fall chinook salmon; WCS - winter chinook salmon; STT - steelhead trout.

Performance Standards to Evaluate Benefits

Benefit Number	Standard / Guideline
B1.	Optimize abundance of anadromous salmonids in Battle Creek by integrating Coleman NFH with Battle Creek Restoration (FCS, LFCS, STT).
B2.	Provide increased harvest opportunity in the Pacific Ocean commercial and sport fisheries and Sacramento River sport fishery through fulfillment of mitigation responsibilities (FCS, LFCS, STT).
B3.	Restore and create viable, naturally spawning populations (WCS, STT)
B4.	Maintain a secure reserve of genetic resources through a captive broodstock program for a population in danger of extinction (WCS).
B5.	Maintain stock integrity and conserve genetic and life history diversity through proper management of genetic resources (WCS, FCS, LFCS, STT).
B6.	Provide fish for experimental research to investigate specific concerns about fishery resources in the Central Valley (WCS, FCS, LFCS, STT).
B7.	Conduct research to adaptively manage hatchery operations using feedback through monitoring and evaluation. Hatchery operations are monitored to evaluate success of achieving program goals (WCS, FCS, LFCS, STT).
B8.	Improve survival by using proper and progressive incubation, rearing, and release

strategies (WCS, FCS, LFCS, STT).

B9. Improve survival by using disease control and prevention techniques to prevent introduction, spread, or amplification of fish pathogens (WCS, FCS, LFCS, STT).

B10. Enhance local, state, and regional economies (FCS, LFCS, STT).

Performance Standards to Evaluate Risks

Risk Number	Standard / Guideline
R1.	Minimize potential negative effects of hatchery operations on natural populations of anadromous fishes in Battle Creek (FCS, LFCS, STT).
R2.	Minimize potential interactions between juvenile hatchery- and natural-origin salmonid stocks by using proper rearing and release strategies (WCS, FCS, LFCS, STT).
R3.	Prevent introduction, spread, or amplification of fish pathogens on natural stocks through the use of disease control and disease prevention techniques (WCS, FCS, LFCS, STT).
R4.	Minimize potentially deleterious genetic effects of hatchery operations on listed and candidate natural stocks by employing genetically conscious management strategies (WCS, FCS, LFCS, STT).
R5.	Avoid exceeding the carrying capacity of fluvial, lacustrine, estuarine, and ocean habitats (WCS, FCS, LFCS, STT).
R6.	Conduct research to adaptively manage hatchery operations using feedback through monitoring and evaluation. Hatchery operations are monitored to evaluate potential impacts of the program on natural salmonid stocks (WCS, FCS, LFCS, STT).

1.10 List of program performance indicators, designated by benefits and risks

The following performance indicators can be used to monitor and evaluate the aforementioned benefits and risks of fish propagation at Coleman NFH and Livingston Stone NFH. Also listed with performance indicators are relevant fish culture practices and constraints. Relevant fish culture practices are actions conducted at Coleman NFH and Livingston Stone NFH that attempt to maximize benefits and minimize potential risks of the artificial propagation programs. Constraints limit the ability to achieve or monitor performance standards.

Similar to the performance standards, performance indicators have been separated into two categories: benefits (B) that the hatchery program will provide to the listed species or by meeting program objectives; and risks (R) that may be posed by the hatchery program to listed populations.

Performance Indicators Addressing Benefits

Performance Standard B1: Optimize abundance of anadromous salmonids in Battle Creek by integrating Coleman NFH with Battle Creek Restoration (FCS, LFCS, STT)

Intensive restoration of the Battle Creek watershed is underway. Because Coleman NFH is located on Battle Creek, restoration of anadromous fish habitat and populations in that watershed must be considered together with facility operations and management at Coleman NFH.

Coleman NFH receives all of its water and nearly all of its broodstock from Battle Creek. Battle Creek also serves as the receiving waters for nearly all juveniles produced at Coleman NFH. As a result, fish production at Coleman NFH is intimately tied to the Battle Creek watershed. In recent years, estimates of adult contribution to total returns in Battle Creek are roughly 90% hatchery-origin. Even in a fully restored Battle Creek watershed (meeting production goals of the Anadromous Fish Restoration Program) returns of hatchery-origin adults will comprise a significant portion of total returns. Because they are tied so closely together, the Service believes that Battle Creek and Coleman NFH must be managed as a single, complex system in order to achieve optimum benefits from the Battle Creek restoration process concomitant with fulfilling the mitigation responsibilities associated with the construction of Shasta Dam. The following fish culture operations may be viewed as providing direct benefits to achieving restoration goals in Battle Creek:

Relevant fish culture practices:

- Management of fish passage and monitoring at the Coleman barrier weir permits controlled passage and monitoring of chinook salmon and steelhead trout into the upper Battle Creek watershed. Management of fish passage at the barrier weir allows for segregation and enumeration of runs at that point, thus affording the capability to measure and maximize restoration benefits for "at-risk" priority stocks
- Steelhead trout returning to Coleman NFH in excess of broodstock requirements are passed above the Coleman barrier weir to spawn naturally and contribute to the re-establishment of a viable population in that tributary
- Fall chinook salmon adults returning to Battle Creek in excess to broodstock needs at Coleman NFH are allowed to spawn naturally below the barrier weir and contribute heavily to natural production in this system
- Hatchery-origin late-fall chinook salmon spawn naturally below the barrier weir and contribute substantially to natural production in that system. Additionally, natural-origin late-fall chinook salmon collected a Coleman NFH are passed above the barrier weir to spawn naturally in upper Battle Creek

- Carcasses of returning hatchery-origin adults supply marine-derived nutrients to the Battle Creek watershed ecosystem as well as the upper Sacramento River

Performance Indicators:

- Continue to monitor numbers of hatchery- and natural-origin adults during spawning operations
- Continue to conduct Service video monitoring and adult trapping at the Coleman barrier weir to enumerate passage of hatchery- and natural-origin adults from March through September 1
- Continue to acquire and analyze CDFG run-size estimates at the Red Bluff Diversion Dam (RBDD) and in lower Battle Creek
- Continue other Service monitoring programs in Battle Creek (e.g., juvenile emigration monitoring) to assess current and future levels of natural production within Battle Creek

Other Indirect Indicators and Achievements:

- As part of the Battle Creek Working Group (BCWG), assisted in the development of a restoration plan for Battle Creek, with the intent to integrate operations at Coleman NFH
- Conducted a public re-evaluation of Coleman NFH, where alternative hatchery management strategies were elicited in regards to integrating Coleman NFH with restoration of Battle Creek
- Acquired funding and initiated design for improving the barrier weir and fish ladder at Coleman NFH. Modifications to the existing structure will allow for improved control of fish passage into upper Battle Creek by decreasing numbers escaping above the barrier weir
- Finished construction of an ozone water treatment system at Coleman NFH. Water treatment capabilities of the new system will alleviate concerns of passing potentially disease-carrying fish into upper Battle Creek, the hatchery's water source
- Developed an analysis of water intakes that supply Coleman NFH considering both interim and long-term solutions. Accomplished interim modifications at existing intake structures to provide improved protection for naturally produced chinook salmon and steelhead trout in the upper Battle Creek watershed. Currently seeking funding for construction of long-term solution
- Conducted field research of habitat use by ESA-listed winter and spring chinook salmon in upper Battle Creek (1995 through 1998; USFWS, RBFWO in progress)

Constraints:

- Funding for permanent intake improvements has not been secured.
- High flows decrease the effectiveness of the barrier weir at blocking upstream passage.
- Environmental conditions (e.g., turbidity, vegetation, high flows) during trapping operations and video monitoring at the barrier weir may decrease our ability to monitor upstream migration while the fish ladder is open.
- Over-escapement of hatchery-origin chinook salmon (caused in part by reduction in harvest opportunities) presents management difficulties in Battle Creek.

Performance Standard B2: Increase or maintain harvest opportunities for commercial and sport fisheries (FCS, LFCS, STT)

With development of the CVP, including construction of the Coleman NFH, the federal government assumed responsibility for mitigating anadromous fishery losses caused by the construction of Shasta Dam. A primary objective of Coleman NFH fall and late-fall chinook salmon propagation programs is to provide for a viable ocean-troll commercial fishery and ocean/freshwater recreational fisheries while protecting depressed natural populations. Present day ocean harvest of chinook salmon in California primarily occurs south of Point Arena. Central Valley chinook stocks comprise an estimated 85-95% of total catch south of Point Arena and a lesser proportion of harvest north of Point Arena. Hatchery-origin chinook salmon comprise the majority of total harvest south of Point Arena, and fall chinook salmon from Coleman NFH comprise approximately 20% of this harvest. Mark/recapture and coded-wire tag (CWT) data are used to estimate contribution to ocean and river fisheries.

Relevant fish culture practices:

- All fish culture and release practices at Coleman NFH and Livingston Stone NFH are intended to maximize survival of hatchery fish, while minimizing negative effects on natural salmonid stocks in the Sacramento River and Battle Creek

Performance Indicators:

- Estimate contribution (rates and total numbers) of Coleman NFH fall and late-fall chinook salmon to Pacific Ocean commercial and sport fisheries and the Sacramento River sport fishery. (Note: Harvest estimates for fall and late-fall chinook salmon are presented in two formats in this document, by harvest year and brood year, to facilitate interpretation of harvest levels attributable to fish propagation at Coleman NFH)
- Monitor Coleman NFH-origin fall and late-fall chinook salmon contribution to fisheries as a proportion of the Central Valley Abundance Index (ocean harvest plus river escapement) as reported by Pacific Fishery Management Council (PFMC)(1999)
- Estimate sport harvest of Coleman NFH fall and late-fall chinook salmon in the Sacramento River
- Monitor ocean contribution rates of hatchery-origin winter chinook salmon as an index of harvest on naturally-produced winter chinook salmon
- Conduct on-site bio-sampling of returning adults for mark identification and CWT retrieval to develop indices of escapement

Other Indirect Indicators and Achievements

- Initiated a study to examine and define mitigation responsibilities of Coleman NFH on a biological basis (i.e., what was the actual decrease in potential production of salmon and steelhead attributable to Shasta Dam) using: 1) records of historic harvest; and, 2) analysis of potential spawning habitat above Shasta Dam (in progress)

Constraints:

- Propagation of fish at Coleman NFH can increase *harvest opportunity*; however, the total number of fish *actually harvested* in the mixed-stock ocean fishery has been restricted to protect ESA listed stocks.
- Over-escapement of hatchery-origin chinook salmon, caused in part by reduction in harvest opportunities due to more stringent fishing regulations, causes management difficulties in Battle Creek.
- Determination of actual mitigation responsibility remains difficult because of disparate information.

Performance Standard B3: Assist in the restoration of listed stocks of anadromous salmonids (WCS, STT)

Restoration and recovery of fish and aquatic ecosystems are the highest priority for the National Fish Hatchery System. Artificial propagation of winter chinook salmon at Livingston Stone NFH is conducted to supplement the natural population in the Sacramento River. The basis for the winter chinook supplementation program is that hatchery production can provide a higher survival from egg-to-smolt life stages than occurs naturally. The Service's winter chinook supplementation program is temporary, and will terminate when the natural population has achieved the recovery goal set forth in the Draft Sacramento Winter Chinook Salmon Recovery Plan (NMFS 1997; see also Section 1.15).

Artificial propagation of steelhead at Coleman NFH is used to supplement the naturally producing population in this tributary. Steelhead trout returning to Coleman NFH in excess of broodstock requirements are passed above the Coleman barrier weir to spawn naturally with the goal of re-establishing a viable population in Battle Creek.

Relevant fish culture practices:

- Use elements of the Natural Rearing Enhancement System (NATURES; Maynard et al. 1996a, 1996b) to improve survival and reduce potential genetic selection pressures induced by hatchery rearing (WCS, STT)
- Rear fish using parent waters to facilitate strong homing and promote integration of hatchery fish with the natural population(s) they are intended to supplement (WCS, STT)
- Developed a separate facility designed specifically for supplementing Sacramento River winter chinook salmon (WCS)
- Collect few natural broodstock (maximum of 15% of estimated total run) to lower the demographic and genetic risks to the naturally spawning population (WCS)
- Develop, refine, and use genetic discrimination techniques to effectively identify and spawn only target broodstock (WCS)
- Use factorial-type mating strategy to maximize effective population size (WCS)
- Use a 1:1 mating strategy to maintain genetic diversity of hatchery stock (STT)
- Collect and spawn many broodstock to maximize genetic variability of hatchery stock (STT)

- Complete (100%) marking of hatchery production (WCS, STT)
- Passage of excess broodstock to re-colonize upper Battle Creek (STT)

Performance Indicators:

- Continue to conduct field surveys to generate adult run-size estimates and evaluate survival, spawning success, and integration of hatchery propagated winter chinook salmon with the natural population
- Monitor and evaluate genetic risks of the winter chinook propagation program (calculate effective population size [N_e] annually at time of juvenile release) to measure potential genetic effects on the natural population
- Evaluate effectiveness of the winter chinook salmon propagation program at Livingston Stone NFH for assisting restoration by comparing estimates of replacement rates for hatchery propagated fish to estimated replacement rates for naturally produced fish. It is assumed that the winter chinook salmon hatchery propagation program benefits restoration goals when hatchery:natural replacement rates are equal to or greater than 1.0
- Use juvenile emigration data (e.g., abundance, life stage, timing) collected by rotary screw trapping to assess the effectiveness of steelhead trout adult relocations in upper Battle Creek.
- Monitor adult steelhead returning to Coleman NFH and passing the barrier weir to document changes in abundance of naturally-produced steelhead in the system

Other Indirect Indicators and Achievements

- Conducted an investigation of life-history strategy (e.g., anadromous vs. non-anadromous) of hatchery-propagated steelhead to provide information leading to improved broodstock selection strategies

Constraints:

- Monitoring progress of recovery effort is difficult because of inadequacies and discrepancies in abundance estimates for winter chinook salmon in the upper Sacramento River (e.g., between the carcass survey and RBDD counts).
- Genetic discrimination techniques are expensive and time consuming.

Performance Standard B4: Create a genetic reserve for an endangered species through a captive broodstock program (WCS)

Captive propagation of winter chinook salmon is a collaborative project between the Service, BML, and Steinhart Aquarium, and requires involvement from many resource agencies and resource groups (e.g., USBR and DWR). The primary purpose of the captive broodstock program is to protect a portion of each year-class against potential catastrophes that could decimate the endangered winter chinook population in the natural environment. Currently the program focuses on: 1) investigations to synchronize maturation timing; 2) investigations to improve gamete quality; 3) investigations of smoltification physiology/ methodology; 4) investigations of gamete cryopreservation techniques; and, 5) modifying and increasing monitoring efforts to assure adequate in-river recovery of released juveniles for program evaluation.

Relevant fish culture practices:

- To reduce genetic risks, captive broodstock are maintained for only one generation (i.e., progeny of captive broodstock will not be included in the subsequent selection of future captive broodstock candidates)
- Effective population size of captive broodstock is maximized by incorporating equal numbers of progeny from each family group or combination of family groups produced at the Livingston Stone NFH
- Developed state-of-the art fish husbandry practices to rear chinook salmon to maturity in captivity

Performance Indicators:

- Achieve maturation of captive broodstock at appropriate age and time
- Collect viable gametes from mature captive broodstock at appropriate age, size, and time

Other Indicators and Achievements:

- Developed a genetic repository to preserve population diversity for current and future recovery efforts
- Minimize precocial maturation of captive broodstock, particularly males, by decreasing growth rate (through food rationing)

Constraints:

- Experienced difficulties with asynchronous maturation of captive broodstock and the natural population.
- Captive broodstock generally produce less viable gametes.
- Disease organism (Rosette agent) previously limited tranfers of live fish from the broodstock programs.
- Transferring gametes decreases their viability (cryopreserved and fresh).

Performance Standard B5: Maintain stock integrity and conserve genetic and life history diversity (WCS, FCS, LFCS, STT)

Fish culture practices at Coleman NFH and Livingston Stone NFH are designed to maintain stock integrity, conserve genetic and life history diversity, and minimize divergence from natural populations. Adult broodstock are collected across a range of phenotypic characteristics including: run timing, age, sex ratio, and any other observed traits. Large numbers of broodstock are also spawned (LFCS, FCS, STT). In addition, both natural- and hatchery-origin adults are used as hatchery broodstock. These practices of broodstock selection are believed to help protect the long-term fitness of the hatchery stock and minimize potential risks to natural populations by decreasing divergence between hatchery and natural populations.

Relevant fish culture practices:
- Use locally-collected, natural- and hatchery-origin adults for broodstock
- Spawn the number of adults necessary to minimize genetic drift and inbreeding, and conserve genetic variability of the stock
- Collect and spawn adults throughout the duration of run/spawn timing, modeling the spawning schedule after a normal (bell-shaped) distribution
- Use a paired mating strategy (i.e., 1 male to fertilize 1 female) (FCS, LFCS, STT)
- Use at least two males (if possible) to fertilize each female, and use males two but no more than four times (WCS)
- Use phenotype and mark status to effectively identify and spawn only the target population
- Incorporate naturally-produced fish as hatchery broodstock
- Randomly select broodstock from collected adults. Avoid artificial selection of broodstock based on phenotypic traits (i.e., size)
- Use natal stream water at ambient temperature to reinforce genetic compatibility with local environments and promote homing
- Use genetic discrimination techniques to effectively identify target broodstock (WCS)

Performance Indicators:
- At the conclusion of each spawning season, analyze CWT's from spawned fish to verify selection of target broodstock
- Analyze trends in fecundity, return rates, return timing, spawn timing, adult size and age composition, survival for different life stages, and other parameters as surrogates for measures of "fitness" of the hatchery stock

Other Indirect Indicators and Achievements
- Conducted an investigation of life-history strategy (e.g., anadromous vs. non-anadromous) of hatchery-propagated steelhead to provide information leading to improved broodstock selection strategies (USFWS, RBFWO in progress)

Constraints:
- Inability to mark all of the fall chinook production limits complete differentiation of hatchery and natural stocks based on mark status and hinders absolute differentiation between different hatchery runs based on mark status.
- Genetic discrimination is not available for all runs of chinook salmon.
- Public and political pressures have limited the use of culling as a tool to manage the distribution of egg take. Similar pressures also impose constraints on the number of broodstock spawned for a founding population.

Performance Standard B6: Provide fish for experimental purposes (WCS, FCS, LFCS, STT)

Investigators from government agencies, academic institutions, and the private sector request fish from Coleman NFH to study a variety of issues, including: Central Valley water management alternatives, bypass efficiencies, monitoring efficiencies, and fish health, performance and physiology. In these investigations, fall and late-fall chinook salmon propagated at Coleman NFH are often used as surrogates for ESA-listed winter and spring chinook salmon, which are generally not available for research purposes. Additionally, Coleman NFH provides fish for educational and outreach purposes, including an annual "Return of the Salmon Festival."

Relevant fish culture practices:

- Spawn and rear fish in a manner conducive to the execution of the experiment
- Experimental releases are generally marked and coded-wire tagged prior to release

Performance Indicators:

- As appropriate for specific experimental design

Constraints:

- Current size and configuration of rearing units limits flexibility of lot sizes.
- Potential for increased interaction with ESA listed and candidate stocks following release.
- Potential for reduced contribution of experimental groups.

Performance Standard B7: Conduct research to monitor and evaluate hatchery operations and practices (WCS, FCS, LFCS, STT)

Standard and proven fish culture practices are used at Coleman NFH and Livingston Stone NFH to produce fish necessary to accomplish program goals (mitigation, supplementation, and/or conservation/preservation), while minimizing the potential for negative effects on natural stocks. Extensive monitoring and evaluation are conducted on- and off-site in order to adapt and improve standard fish culture methods. Knowledge gained through experimentation and research is used to modify fish culture practices, when appropriate, to better accomplish program goals.

Relevant fish culture practices:

- All existing fish culture practices at Coleman NFH and Livingston Stone NFH

Performance Indicators:

- Evaluate contribution of fall and late-fall chinook salmon to ocean fisheries
- Continue mark screening and mark/tag recovery efforts on adults returning to Coleman NFH, the Keswick Dam Fish Trap, and the RBDD
- Continue to collect and analyze information obtained through adult trapping and video monitoring at the Coleman barrier weir in Battle Creek
- Summarize and analyze ocean harvest data (Pacific States Marine Fisheries Commission)

- Summarize and analyze information collected during Battle Creek and mainstem Sacramento River adult carcass surveys
- Analyze information collected from juvenile emigration monitoring programs on Battle Creek and the Sacramento River

Other Indicators and Achievements
- Solicited comments and expertise in a public forum regarding how the Service could better use Coleman NFH and Livingston Stone NFH to accomplish program goals (Coleman NFH Re-evaluation process)
- Developed and initiated a study to examine genetic variability between and within steelhead trout propagated at Coleman NFH, the Sacramento River, and several tributaries to the Sacramento River. This investigation will provide genetic information regarding the potential utility of hatchery steelhead trout from Coleman NFH in future recovery efforts (USFWS, RBFWO in progress)

Constraints:
- Current funding and logistics prevent marking all hatchery-origin fall chinook salmon.
- Environmental conditions (e.g., high flows and tubidity) hinder field research and monitoring efforts.

Performance Standard B8: Improve survival of propagated species/stock using appropriate incubation, rearing, and release strategies (WCS, FCS, LFCS, STT)

The Service plans to continue improving the survival of fish produced at Coleman NFH and Livingston Stone NFH to accomplish the following program objectives: 1) provide harvest opportunity (FCS, LFCS, STT); 2) ensure adequate escapement to the hatchery for broodstock purposes (FCS, LFC, STT); and, 3) supplement the natural populations (WCS, STT). Fish culture and release practices at Coleman NFH and Livingston Stone NFH are intended to improve the survival of hatchery fish, both before and after release, and minimize negative effects on natural salmonid populations and the Sacramento River watershed.

Relevant fish culture practices:
- Release fish at a time and size to improve survival and minimize potential negative effects on natural stocks in freshwater
- To the extent possible, rear fish at densities favorable for minimizing stress, disease and mortality during all life stages
- Release fish at locations that maximize survival while minimizing straying from the hatchery
- Use disease prevention and control techniques to maximize survival
- Conduct studies to investigate effects of alternative: food types; rearing densities; ponding strategies; natural-type rearing elements; size, time, and location of release; and other factors.

Apply knowledge gained through investigations to modify hatchery practices, when appropriate, to maximize survival and minimize potential negative effects on natural stocks

Performance Indicators:

- Analyze trends in survival for different life stages at the hatchery
- Analyze trends in rates of ocean harvest, freshwater harvest, and escapement

Constraints:

- Rearing densities at Coleman NFH are dictated largely by the size of the production programs, the availability of rearing space, and the availability of water for hatchery use. Ponding at Coleman NFH is generally managed to maximize the use of hatchery rearing space, while maintaining densities necessary for fish culture.
- Release locations and timing are chosen to maximize survival while minimizing effects on natural stocks. Therefore, upriver release locations are generally used to minimize stray rates and geographic distribution of hatchery-origin strays (although releasing fish lower in the system would improve overall survival to maturity and contribution of adults). Likewise, timing of releases is adjusted to minimize potential effects on natural stocks (see Section 10).

Performance Standard B9: Improve survival by preventing disease introduction, spread, or amplification (WCS, FCS, LFCS, STT)

The primary goal of fish health management programs at Coleman NFH and Livingston Stone NFH is to produce healthy fish that will contribute to program goals of mitigation, supplementation, or conservation and preservation, while minimizing the potential for negative effects on natural stocks. This goal is accomplished using state-of-the art technologies in disease prevention along with assistance and technical advice from the Service's California/Nevada Fish Health Center.

Fish culture practices at Coleman NFH and Livingston Stone NFH are designed to produce healthy smolts. Propagation of healthy juveniles will maximize survival and contribution of hatchery fish, both before and after release. The following list details specific projects or activities undertaken at Coleman NFH and Livingston Stone NFH to prevent the introduction, spread, or amplification of fish pathogens from natural populations into hatchery stocks.

Relevant fish culture practices:

- Maintain sanitary conditions for fish rearing including: 1) disinfecting all equipment (e.g., nets, tanks, rain gear, boots, brooms) with iodophor between uses with different fish/egg lots, and 2) disinfecting (with iodophor) the surface of all eggs spawned at the facility
- Constructed and operate an ozone water treatment facility at appropriate capacity to prevent the introduction of pathogens into Coleman NFH through the Battle Creek water supply
- Monitor output and efficacy of the ozone water treatment system

- Enclosed rearing ponds with fencing and bird netting to minimize predation and risks of disease transmitted by predators.
- Prescribe appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) to alleviate disease-contributing factors using approved methods and chemicals
- Conduct applied research leading to improved control of disease epizootics
- Developed and conduct special release strategies to minimize occurrence of disease in hatchery and natural fish
- Developed and execute disease control protocol for marking and tagging of chinook salmon and steelhead trout
- Routinely perform examinations of live fish to assess health status and detect problems before they progress into clinical disease or mortality
- Routinely remove dead and moribund fish from rearing containers. In cases of increased mortality, perform necropsies of diseased and dead fish to diagnose the cause of death
- Perform routine examinations of collected broodstock for disease organisms (viral, bacterial and parasites)

Performance Indicators:

- Analyze survival trends for different life stages at the hatcheries
- Examine trends of ocean harvest, freshwater harvest, and hatchery escapement in regards to documented history of disease incidence at Coleman NFH and Livingston Stone NFH
- Examine on-station mortality of chinook salmon and steelhead trout as percent of total production

Other Indicators and Achievements

- Conducted a post-release evaluation of hatchery-origin smolts to examine disease progression during emigration through the Sacramento River system
- Conducted a survey for Infectious Hematopoietic Necrosis virus (IHNV) in natural-origin fall chinook salmon from Battle Creek and the upper Sacramento River

Constraints:

- Historically, escapement of IHNV-positive fall and late-fall chinook salmon above the hatchery barrier weir has jeopardized hatchery production, especially fall chinook salmon, by shedding the pathogen into the hatchery's water supply. The new ozone water treatment facility should alleviate this concern.
- The source or mode of IHNV transmission at Coleman NFH has not been conclusively identified.
- Power outages or water turbidity may affect the efficacy of the water treatment facility.
- Disease organisms may be introduced through other vectors (birds, mammals, visitors).

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Performance Standard B10: Provide local, state, and regional economic enhancement (FCS, LFCS, STT)

Local, regional, state, and national economies benefit from increased harvest that results from fish propagation programs at Coleman NFH. The economic value of fish production at Colman NFH can be estimated by comparing the direct and indirect value of that portion of the commercial and sport fishery attributable to Coleman NFH with the economic cost of fish production programs at the hatchery. Fish culture and release practices at Coleman NFH and Livingston Stone NFH are designed to improve the survival of hatchery fish, both before and after release, and minimize negative effects on natural salmonid populations and the Sacramento River watershed.

Relevant fish culture practices:

- Release fish at a time and size to improve survival and minimize effects on naturally-produced stocks
- To the extent possible, rear fish at densities favorable for minimizing stress, disease, and mortality during all life stages
- Release fish at a location to maximize survival, while minimizing straying from the hatchery
- Use disease prevention and control techniques to maximize survival
- Conduct studies to investigate effects of alternative: food types; rearing densities; ponding strategies; natural-type rearing elements; size, time, and location of release; and other factors. Apply knowledge gained through investigations to modify hatchery practices, when appropriate, to maximize survival and minimize potential negative effects on natural stocks

Performance Indicators:

- Estimate direct and indirect economic enhancement of local, state, and regional economies resulting from propagation programs at Coleman NFH by calculating input to local economy and commercial and sport value of the fishery attributable to the hatchery

Constraints:

- Artificial propagation can increase harvest opportunity; however, ocean harvest in a mixed-stock fishery is restricted to protect listed stocks.
- Cost/benefit analysis, in terms of absolute economics, is inappropriate for mitigation and restoration/recovery programs for listed stocks.

Performance Indicators Addressing Risks

Performance Standard R1: Minimize potential negative effects of Coleman NFH on restoration of Battle Creek (FCS, LFCS, STT)

Relevant fish culture practices:

- Screen water intakes for Coleman NFH to prevent entrainment of fish from Battle Creek upstream of the hatchery

- Water use at Coleman NFH is non-consumptive so water used for propagating fish at the hatchery is returned to the creek immediately below the hatchery
- Operate pollution abatement pond as appropriate to meet the National Pollution Discharge Elimination System (NPDES) water quality discharge criteria
- Manage fish passage at the Coleman barrier weir in a manner congruent with both restoration of Battle Creek and broodstock collection needs at the hatchery. Passage above the barrier weir is blocked and fish are congregated during periods necessary for collection of broodstock for the propagation programs. Operation of the barrier weir fish ladder and associated monitoring programs outside the period of broodstock collection will be determined by the Battle Creek Adaptive Monitoring Program
- Juvenile release strategies are designed to promote rapid emigration from Battle Creek

Performance Indicators:

- Analyze natural production in Battle Creek below and above the hatchery barrier weir
- Monitor emigration of hatchery releases to document rates of movement
- Monitor quality of effluent water from Coleman NFH

Other Indicators and Achievements

- Conducted a public re-evaluation of Coleman NFH, where alternative hatchery management strategies were elicited in regards to integrating Coleman NFH with restoration of Battle Creek
- As part of the BCWG, assisted in the development of a Restoration Plan for Battle Creek that integrates operations at Coleman NFH
- Conducted an analysis of water intakes that supply Coleman NFH. Accomplished interim modifications at existing intake structures to provide improved protection for naturally produced chinook salmon and steelhead trout in the upper Battle Creek watershed. Initiated an analysis of long-term alternatives for water intakes at Coleman NFH. Currently seeking funding to accomplish construction
- Acquired funding and initiated design for renovating the barrier weir and fish ladder at Coleman NFH. Modifications to the existing structure will allow for improved control in the management of fish passage into upper Battle Creek
- Constructed and operate a water treatment facility to prevent the introduction of pathogens into Coleman NFH through the Battle Creek water supply. This action alleviates concerns of passing potentially disease carrying fish above the hatchery's barrier weir, allowing additional adult passage opportunity into natural spawning habitats

Constraints:

- Conflicts may arise between the Battle Creek restoration and Coleman NFH mitigation responsibilities.
- Funding is currently not available for intake improvements.
- Environmental conditions (e.g., turbidity, vegetation, high flows) during trapping operations and video monitoring at the barrier weir may decrease our ability to monitor upstream migration while the fish ladder is open.

- Over-escapement of hatchery-origin chinook salmon, caused in part by reduction in harvest opportunities, presents management difficulties in Battle Creek.
- Operation of the Coleman barrier weir for broodstock collection may block or delay migration of naturally-produced adults.

Performance Standard R2: Minimize potential interactions between hatchery- and natural-origin stocks (FCS, LFCS, WCS, STT)

Artificial propagation programs at Coleman NFH and Livingston Stone NFH are designed to achieve program goals of mitigation, augmentation, supplementation, or conservation and preservation, with the additional goal of minimizing the potential for negative effects on natural stocks.

Relevant fish culture practices:
- Propagate only native stocks collected from the upper Sacramento River
- Minimize potential interactions in the freshwater environment by releasing fish at a time, size, physiological condition, and location that promote rapid emigration and minimal straying
- Monitor natural- and hatchery-origin adult salmon in Battle Creek above the hatchery using the Coleman barrier weir

Performance Indicators:
- Analyze stray rates of fall and late-fall chinook salmon, comparing groups released at different sizes and at different locations
- Analyze emigration rates and timing of hatchery- and natural-origin chinook salmon and steelhead trout

Other Indicators and Achievements
- Terminated the established practice of releasing fry

Constraints:
- Environmental conditions limit field monitoring capabilities.

Performance Standard R3: Do not introduce, spread, or amplify pathogens of natural stocks (FCS, LFCS, WCS, STT)

The primary goal of fish health management programs at Coleman NFH and Livingston Stone NFH is to produce healthy fish that will contribute to program goals of mitigation, supplementation, or conservation and preservation, while minimizing the potential for negative effects on natural stocks. This goal is accomplished using state-of-the art technologies in disease prevention along with assistance and technical advice from the Service's California/Nevada Fish Health Center (CA/NV FHC).

Fish culture practices at Coleman NFH and Livingston Stone NFH are designed to produce healthy smolts. Propagation of healthy juveniles will maximize survival and contribution of hatchery fish, both before and after release. It is equally important to minimize potential negative effects that releasing diseased fish may have on natural salmonid populations. The following list details specific projects or activities undertaken at Coleman NFH and Livingston Stone NFH to prevent the introduction, spread, or amplification of fish pathogens from hatchery stocks into natural populations.

Relevant fish culture practices:

- Constructed an ozone water treatment facility to prevent the introduction of pathogens into Coleman NFH through the Battle Creek water supply
- Developed and conduct special release strategies to minimize occurrence of disease in hatchery fish and decrease the potential for transmission of diseases to natural fish
- Developed and conduct a disease control protocol for marking and tagging chinook salmon and steelhead trout
- Maintain sanitary conditions for fish rearing including: 1) disinfecting all equipment (e.g., nets, tanks, rain gear, boots, brooms) with iodophor between uses with different fish/egg lots, and 2) disinfecting (with iodophor) the surface of all eggs spawned at the facility
- Prescribe appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) to alleviate disease-contributing factors using approved methods and chemicals.
- Conduct applied research on-site to control disease epizootics
- Routinely remove dead and moribund fish from rearing containers. Perform necropsies of diseased and dead fish to diagnose the cause of death
- Perform routine examinations of collected broodstock for disease organisms (bacterial, viral and parasites)
- Routinely perform examinations of juveniles to assess health status and detect problems before they progress into clinical disease or mortality

Performance Indicators:

- Examine trends of ocean harvest, freshwater harvest, and hatchery escapement in regards to documented history of disease incidence at Coleman NFH and Livingston Stone NFH
- Examine on-station mortality of chinook salmon and steelhead trout as proportion of total production

Other Indicators and Achievements

- Conducted an investigation to examine the mode(s) and potential for IHNV transmission between hatchery- and natural-origin chinook salmon
- Conducted a post-release evaluation of hatchery-origin smolts to examine disease progression during emigration

- Conducted a survey for IHNV in natural-origin fall chinook salmon from Battle Creek and the upper Sacramento River
- Assessed ecological risk of disease transmission to natural stocks.

Constraints:
- It is difficult to determine actual disease prevalence or actual disease transmittance in natural stocks.

Performance Standard R4: Minimize the potential for negative genetic effects of artificial propagation programs on natural stocks (FCS, LFCS, WCS, STT)

Fish propagation practices at Coleman NFH and Livingston Stone NFH are conducted so that artificially propagated fish remain genetically similar to naturally-producing populations in the upper Sacramento River. Minimizing genetic divergence between hatchery and natural populations decreases the possibility of hatchery-origin fish having deleterious genetic effects on natural stocks when interbreeding occurs. Broodstocks are also selected to minimize possibilities of interbreeding between different stocks (e.g., winter and spring or fall and late-fall). Some fish culture practices that are employed at Coleman and Livingston Stone NFH's to accomplish this task are listed below.

Relevant fish culture practices:
- Use phenotype and mark status to effectively identify and spawn only the target population (fall and late-fall chinook)
- Manage egg take to ensure all portions of the run are represented in the spawning distribution
- Use natal stream water at ambient temperature to reinforce genetic compatibility with local environments
- Use only native stocks from the upper Sacramento River in propagation programs
- Incorporate naturally produced fish as hatchery broodstock
- Spawn numbers of adults necessary to minimize genetic drift and inbreeding, and to conserve genetic variability of the stock. Large numbers >200 adults (STT, LFS, FCS) and up to 120 (WCS)
- Collect and spawn adults throughout the duration of run/spawn timing, modeling the spawning distribution after a normal, bell-shaped curve
- Use the appropriate mating strategy: 1 male to fertilize 1 female (FCS, LFC, STT)
  Factorial-type mating (e.g., 2 males to fertilize each female) (WCS)
- Randomly select broodstock from collected adults. Avoid artificial selection of broodstock based on phenotypic traits

Performance Indicators:
- Analyze CWT's following each spawning season to verify selection of target broodstock

- Monitor and analyze trends in fecundity, survival for different life stages, return rates, return timing, spawn timing, adult size and age composition, and other parameters to indicate potentially deleterious changes occurring in the hatchery stock
- Calculate effective population size estimates for releases of juvenile winter chinook salmon
- Evaluate the effects of over-escapement on net production in Battle Creek by analyzing juvenile production estimates

Other Indicators and Achievements

- Developed genetic discrimination techniques to effectively identify target broodstock (winter chinook only)
- Analyzed broodstock history and incorporation with natural stocks
- Analyzed stray rates of fall and late-fall chinook salmon, comparing groups released at different sizes and at different locations

Constraints:

- Cost of genetic monitoring is expensive and time consuming, inhibiting wide-spread use.
- Current genetic technologies cannot discriminate between all stocks of chinook salmon on an individual basis.
- Overlap of run/spawn timing of stocks such as winter/spring, spring/fall, and fall/late-fall may lead to hybridization.

Performance Standard R5: Do not exceed carrying capacity of freshwater, estuarine or ocean habitats (FCS, LFCS, WCS, STT)

Relevant fish culture practices:

- Release juvenile salmon and steelhead trout at or near "smolt" stage to decrease time spent in freshwater, minimizing the potential for competition with naturally-produced juvenile fish
- Cull large numbers of fall and smaller numbers of late-fall chinook salmon

Performance Indicators:

Freshwater

- Evaluate emigration rates of hatchery-origin juveniles to verify rapid emigration
- Monitor returns of natural and hatchery adults
- Monitor juvenile production from naturally spawning salmonids in Battle Creek

Estuarine

- Limited data available

Ocean

- Limited data available

Constraints:

- Little information is available concerning estuarine or ocean rearing characteristics of fish released from Coleman NFH or Livingston Stone NFH.

- Carrying capacity has not been determined for freshwater, estuarine, or ocean environments.
- Fulfilling mitigation responsibilities and broodstock requirements may result in over-escapement of hatchery stocks to Battle Creek. It may not be possible to remove all of these individuals from Battle Creek.

Performance Standard R6: Conduct research to evaluate potential effects on natural stocks and adaptively manage hatchery operations and activities (FCS, LFCS, WCS, STT)

Extensive monitoring and analyses are conducted to evaluate potential negative effects to natural salmonids resulting from fish propagation programs at Coleman and Livingston Stone NFH's. Knowledge gained through experimentation and research is used to modify fish culture practices, when appropriate, to minimize negative effects on natural populations.

Relevant fish culture practices:
- All existing fish culture practices at Coleman NFH and Livingston Stone NFH
- Re-locate excess steelhead above the Coleman barrier weir to supplement natural production in Battle Creek
- Control and monitor passage above the Coleman barrier weir

Performance Indicators:
- Depends on specific experimental designs
- Monitor emigration of juvenile salmonids originating naturally in Battle Creek above and below the barrier weir
- Monitor straying of fall and late-fall chinook salmon produced at Coleman NFH

Other Indicators and Achievements
Conducted a public re-evaluation of Coleman and Livingston Stone NFH's, where potential effects of the artificial propagation programs were assessed. Solicited alternative management strategies that may decrease potential impacts to natural stocks
- In 2000, an interagency agreement was reached to extend (by two months) the duration that salmonids can pass above the Coleman barrier weir into upper Battle Creek.
- Support efforts of USBR to investigate competitive interactions between hatchery- and natural-origin chinook salmon in the Sacramento River
- Investigated mode(s) and potential for IHNV transmission between hatchery- and natural-origin chinook salmon
- Conducted a survey for IHNV in natural-origin fall chinook salmon from Battle Creek and the upper Sacramento River
- Conducted a post-release evaluation of hatchery-origin smolts to examine disease progression during emigration

Constraints:
- Environmental conditions (e.g., flows, turbidity) limit field monitoring capabilities.

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1.11 Expected size of programs

Proposed Annual Number of Broodstock Spawned

Spawning targets at Coleman NFH are approximately 5,200 fall chinook, 540 late-fall chinook, and 400 steelhead trout, with a male to female ratio of 1:1. (Table 1-2). The spawning target for winter chinook salmon at Livingston Stone NFH depends on the estimated upriver escapement of adults for any given brood year. The broodstock collection target for winter chinook salmon is 15% of the estimated upriver escapement, up to a maximum of 120 natural-origin winter chinook salmon broodstock per brood year (i.e., run sizes >800). To maintain genetic diversity, no less than 20 adults will be taken regardless of run size (i.e., run sizes <135). To minimize potential negative effects resulting from natural selection in the hatchery (i.e., domestication), the number of hatchery-origin winter chinook salmon incorporated as broodstock will not exceed 10% of the total number of winter chinook spawned (not including captive broodstock crosses).

The Service is examining the feasibility of satisfying production requirements by spawning larger numbers of broodstock and culling excess eggs. This would help maintain genetic fitness of the hatchery stock and allow jacks to be incorporated at rates much closer to actual return rates. With this change, spawning targets would increase substantially (approximately double). We anticipate that this change in spawning operations will be incorporated within the next two to three years. Prior to implementing this change, the Service will submit a protocol to NMFS requesting approval.

1.12 Proposed annual fish release levels (target number) by life stage and location

Coleman NFH releases a total of approximately 13.6 million chinook salmon and steelhead trout annually (Table 1-2). Fall chinook salmon comprise the majority of fish produced. Annual release targets from Coleman NFH consist of 12 million fall chinook salmon, 1 million late-fall chinook salmon, and 600,000 steelhead trout. Actual production levels may differ from release targets by up to 15% (high or low) because of annual variations in fecundity and survival. Release targets for winter chinook salmon at Livingston Stone NFH are variable, depending upon the estimated upriver escapement of adults for any given brood year. Juvenile capacity of the facility is approximately 250,000 pre-smolts.

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Table 1-2. Annual propagation targets at Coleman and Livingston Stone National Fish Hatcheries are presented, including number of adults spawned, initial egg take, and number of juveniles released. Also shown are target release timing, life stage and size, and release location.

Stock	Spawning		Release				
	Adults (1 ♂ : 1 ♀)	Green Eggs	Number	Month	Life Stage	Size	Location
Coleman NFH							
Fall Chinook[a]	5,200	14,045,000	12,000,000	April	Smolt	75 mm. 90 / lb	Battle Creek at Hatchery
Late-fall Chinook[a,b,c]	540	1,247,000	1,000,000	January	Smolt	135 mm. 13/ lb	Battle Creek at Hatchery
Steelhead Trout[a,d]	400	783,000	600,000	January	Smolt	200 mm. 4 / lb	Sacramento River at Bend (RM 258) and Battle Creek at Hatchery
Livingston Stone NFH							
Winter Chinook	up to 120[e]	variable	≤250,000	January	Pre-smolt	90 mm. 60 / lb	Sacramento River at Redding (RM 298)

a Targets for number spawned and green eggs are back-calculated from the release targets based on estimated fecundity (eggs/female) and estimated survival through various stages of incubation and rearing (see section 9). Unusually high mortality of eggs or fry occurring during the spawning season may necessitate increased number spawned and egg take totals to achieve the release target.

b Approximately 140,000 of the late-fall chinook salmon that are produced are currently released into Battle Creek during November and December to serve as surrogates for spring chinook salmon in an emigration study.

c Approximately 250,000 to 350,000 late-fall chinook salmon are currently transported and released at various locations in the delta to investigate effects of flow and pumping rates on juvenile survival.

d Approximately 150,000 steelhead annually are reared in the Coleman NFH "pre-release" pond. These fish have been released directly into Battle Creek because configuration of that pond does not readily permit collection for transport to an off-site release location. Attempts will be made in 2001 to release all steelhead smolts into the Sacramento River. Only 1,000 to 10,000 are expected to be released into Battle Creek.

e Depends on estimated size of winter spawning population. At least 20 but no more than 120 natural-origin winter chinook salmon will be used as broodstock.

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1.13 Current program performance including estimated smolt-to-adult survival rates, adult production levels, and escapement levels.

Fall Chinook Salmon

For brood years 1973 through 1995, the average rate of **total** estimated contribution per year for fall chinook salmon from Coleman NFH was approximately 0.78% (95% CI, 0.31% - 1.46%) of the total number of juveniles released (including fry and smolts). This is equivalent to approximately 105,000 (95% CI, 69,628 - 139,484) adults annually (Table 1-3). The total estimated contribution includes an average of over 32,000 adults returning to Coleman NFH or spawning naturally in Battle Creek, over 9,000 (95% CI, 4,237 - 14,091) adults harvested annually in the freshwater sport fishery, nearly 60,000 (95% CI, 40,721 - 78,779) adults harvested annually in the ocean commercial fishery, and approximately 6,300 (95% CI, 4,293 - 8,337) adults straying to locations other than Battle Creek (Please refer to Section 3, "Relationship of Program to Other Management Objectives," for derivation of these values and additional information on contribution of Coleman NFH fall chinook salmon). Since brood year 1992 estimated total contribution rates of fall chinook salmon from Coleman NFH have exceeded the long-term average for the facility (Figure 1-2).

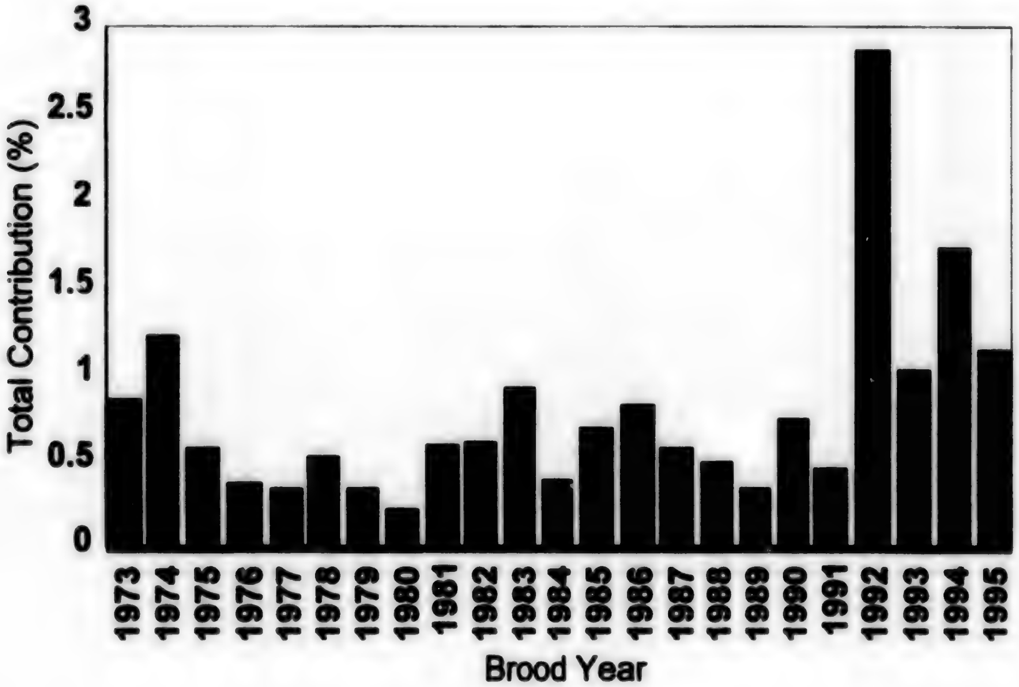

Figure 1-2. Twenty-three year trend of total contribution estimates for Coleman National Fish Hatchery fall chinook salmon. Note dramatic increase beginning with brood year 1992.

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Table 1-3. Estimated ocean harvest, freshwater returns and survival to adulthood for Coleman National Fish Hatchery fall chinook salmon, brood years 1973-1995.

Brood Year	Number Released	Ocean Harvest[a]		Freshwater Returns[b]		Survival to Adult	
		Number	Percent	Number	Percent	Number	Percent
1973	9,386,752	61,857	0.659	19,542	0.208	81,400	0.867
1974	2,497,280	17,126	0.686	13,624	0.546	30,750	1.231
1975	5,580,352	20,119	0.361	12,454	0.223	32,574	0.584
1976	9,791,842	20,512	0.209	16,731	0.171	37,243	0.380
1977	9,626,507	16,999	0.177	16,475	0.171	33,473	0.348
1978	5,704,562	10,889	0.191	18,895	0.331	29,784	0.522
1979	11,687,142	18,500	0.158	22,412	0.192	40,912	0.350
1980	14,494,691	13,642	0.094	19,742	0.136	33,385	0.230
1981	8,991,463	22,870	0.254	30,562	0.340	53,431	0.594
1982	17,035,963	66,389	0.390	38,645	0.227	105,034	0.617
1983	9,986,712	58,461	0.585	35,136	0.352	93,597	0.937
1984	23,424,330	50,739	0.217	41,695	0.178	92,433	0.395
1985	14,613,447	36,374	0.249	64,987	0.445	101,361	0.694
1986	11,802,158	56,849	0.482	41,188	0.349	98,037	0.831
1987	18,152,003	78,111	0.430	27,147	0.150	105,258	0.580
1988	22,172,654	84,301	0.380	23,850	0.108	108,151	0.488
1989	16,866,392	30,966	0.184	26,879	0.159	57,845	0.343
1990	23,372,151	130,217	0.557	43,138	0.185	173,355	0.742
1991	25,302,582	44,850	0.177	73,109	0.289	117,959	0.466
1992	11,916,130	238,217	1.999	103,807	0.871	342,024	2.870
1993	16,660,227	64,544	0.387	108,600	0.652	173,144	1.039
1994	16,178,326	150,932	0.933	128,439	0.794	279,371	1.727
1995	15,967,656	43,567	0.273	140,705	0.881	184,272	1.154
Totals	321,211,322	1,337,031	0.416	1,067,762	0.332	2,404,793	0.749
Average	13,965,710	58,132	0.436	46,424	0.346	104,556	0.782
Std	6,060,324	53,241	0.399	38,359	0.240	80,766	0.575

[a] Based on Section 3, Table 3-5.

[b] Freshwater returns include:

1) Returns to Coleman NFH and Battle Creek modified to 90% of Grand Tab tables as per CDFG (1994) and USFWS (1995);
2) Inriver harvest values for:
   -1975-1987 are calculated as 5% of BC escapement as per Cramer (1991);
   -1988-1990 are calculated as 15% of BC escapement which is an average of Cramer (1991) and PSMFC (1999).
   -1991-1994 are calculated as 25% of BC escapement as per PSMFC (1999).
   -1995 is calculated as 25% of BC escapement based on previous years.
3) Freshwater strays for 1975-1987 are taken from Cramer (1991), 1988-1999 estimated by release group and associated stray index (%) by life stage and release site (See Appendix 10C. Stray Rate Analysis).

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Late-fall Chinook Salmon
For brood years 1989 through 1995, the average estimated rate of total contribution per year for late-fall chinook salmon from Coleman NFH was approximately 0.83% (95% CI, 0.08% - 2.38%) of the total number of juveniles released. This is equivalent to approximately 4,000 (95% CI, 1,151 - 7,016) adults annually (Table 1-4). The total contribution includes an average of over 1,500 (95% CI, 0 - 3,030) adults returning to Coleman NFH, and over 2,500 (95% CI, 1,013 - 1,148) adults harvested annually in the ocean commercial and sport fishery. Please refer to section 3, "Relationship of Program to Other Management Objectives," for additional information on contribution of Coleman NFH late-fall chinook salmon.

Table 1-4. Ocean and freshwater contribution numbers and total contribution percent for late-fall chinook salmon juveniles released from Coleman National Fish Hatchery (brood years 1989-1995).

		Contribution		Total Percent
Brood Year	**Number Released**	**Ocean**	**Fresh Water[a]**	**Contribution**
1989	833,807	271	125[b]	0.047
1990	203,387	1,177	508[c]	0.829
1991	289,028	1,679	723[d]	0.831
1992	322,246	2,911	888	1.179
1993	747,585	2,643	1,087	0.499
1994	621,766	4,501	4,927	1.516
1995	775,890	4,885	2,260	0.921
Total	3,793,709	18,067	10,518	0.753
Average	541,958	2,581	1,503	0.832
STD	263,131	1,695	1,651	0.470

a Freshwater returns are returns to Coleman National Fish Hatchery only (i.e., direct coded-wire tag recoveries).

b Estimated at 0.015% generated by one tagged release group.

c No marked groups were released in this brood year. Freshwater contribution value estimated at 0.25% based on brood year 1991 value.

d Estimated at 0.25% from actual contribution from two tagged groups.

Winter Chinook Salmon
For brood years 1991 through 1995, the average estimated rate of total contribution per year for winter chinook salmon from Coleman NFH was approximately 0.72% (95% CI, 0.02% - 3.37%) of the total number of juveniles released (Table 1-5). The total contribution includes an average of approximately 180 (95% CI, 42 - 322) adults returning to Battle Creek and the upper Sacramento River, and approximately 40 (95% CI, 2- 82) harvested annually in the ocean commercial and sport fishery. Additional information on survival of winter chinook salmon associated with the Service's supplementation program will be presented in an upcoming ESA Section 10 enhancement permit application.

Table 1-5. Ocean and freshwater contribution numbers and total contribution percent for winter chinook salmon juveniles released from Coleman National Fish Hatchery (brood years 1989-1995).

		Contribution		Total Percent
Brood Year[a]	**Number Released**	**Ocean[b]**	**Freshwater[c]**	**Contribution**
1991	10,866	15	na	0.138
1992	27,383	107	88	0.712
1993	17,034	28	273	1.767
1994	41,412	33	266	0.722
1995	48,154	25	100	0.260
Total	144,849	208	727	0.645
Average	28,970	42	182	0.720
STD	15,776	37	101	0.642

[a] Following brood year 1995 the Service entered a moratorium on the capture of natural due to problems associates with imprinting and genetic concerns. Collection of natural-origin adults was resumed in 1998 following the construction of the Livingston Stone National Fish Hatchery (see brief history of the program presented below in Section 1.14.

[b] Expanded recoveries of coded-wire tags from the ocean sport and commercial fishery.

[c] no inland recoveries of winter chinook salmon were made in 1994 from brood year 1991. It is assumed any adults originating from this brood year returned to Battle Creek and were not detected. Monitoring efforts in Battle Creek were initiated in 1995 and is reflected for broodyears 1992 - 1995. Freshwater recovery data for broodyears 1992 - 1994 are complete, while the value displayed for 1995 is draft.

Steelhead Trout

In contrast to Coleman NFH chinook salmon, scant data are available to estimate smolt-to-adult survival rates or stray rates for Coleman NFH steelhead trout. The paucity of data regarding contribution rates of Coleman steelhead trout results from a history of limited tagging of hatchery-origin steelhead trout and the absence of ocean harvest data and freshwater creel data. The best available data on which to estimate contribution rates of Coleman NFH steelhead trout are based on a four year marking and tagging investigation conducted for broodyears 1991 to 1994 (Service, unpublished data). Based on that study, escapement of steelhead trout to Coleman NFH is estimated at 0.32% (95% CI, 0.02% - 0.95%). The current practice of 100% adipose fin-clip marking of steelhead smolts released from Coleman NFH will facilitate the future generation of these important estimates.

1.14 Date programs started

Fall Chinook Salmon

Fall chinook salmon from have been artficially propagated at Battle Creek since 1895. From 1895 to 1942, fall chinook salmon were propagated at the battle Creek Egg Taking Station. In 1943, Coleman NFH was completed, and fall chinook have been propagated here every year since then.

Late-fall Chinook Salmon

Late-fall chinook were not formally recognized as distinct from fall chinook salmon at Coleman NFH until 1973. However, by about 1954 fish culturists at Coleman NFH recognized differences between these stocks and began propagating them separately from spawning through rearing (see Appendices 6A on fall and late-fall chinook broodstock collection locations and 8A on spawn timing at Coleman NFH). Distinctions between the "early" and "late" fall runs were based on differences in run/spawn timing and location of broodstock collection. Early-spawning fish collected at Battle Creek (i.e., fall chinook) were separated from late-spawning fish collected at the Keswick Dam fish trap (i.e., late-fall chinook). Propagation of late-fall chinook salmon at Coleman NFH was completely separated from fall chinook salmon propagation in 1973.

Winter Chinook Salmon

An initial attempt to hold and propagate winter chinook salmon at Coleman NFH was made in 1955. In 1955, the Keswick trap was operated during the last two weeks in March, and about 200 winter chinook salmon were hauled to Coleman NFH and held until maturity. The original objectives of the program, as outlined in Azevedo and Parkhurst (1958), were to:

1) Save salmon fry that would otherwise be lost to diversion at ACID Dam;
2) Obtain an index of the size of the winter chinook;
3) Learn the migration pattern of the winter chinook; and,
4) Determine the value and best methods of artificially propagating winter chinook salmon.

This initial attempt, as well as several subsequent efforts from 1958 through 1967, was largely unsuccessful. Similarly, from 1978 through 1985, additional attempts to propagate winter chinook salmon at Coleman NFH met with limited success. Stress and high water temperatures at the hatchery resulted in substantial mortality of broodstock, eggs, and juveniles. In 1988, with a decline in the natural winter chinook salmon population and a petition to list winter chinook salmon as threatened under the ESA pending, the Service re-committed to developing a propagation program for winter chinook salmon at Coleman NFH. The goal of the resurrected winter chinook propagation program at Coleman NFH was recovery of winter chinook salmon in the upper Sacramento River.

Winter chinook salmon were propagated at Coleman NFH from 1989 through 1995. During 1996 and 1997, in response to concerns related to genetic integrity and the improbability of reproductive assimilation of hatchery adults with the natural winter chinook salmon population (because hatchery-origin adults returned to Battle Creek rather than the Sacramento River), the Service imposed a moratorium on collecting natural winter chinook salmon for the propagation program. Adults from the captive broodstock program were used as broodstock, and small numbers of juveniles were released for brood years 1996 and 1997 (4,718 and 21,271 respectively). The winter chinook salmon propagation program was re-initiated in 1998 because refined broodstock selection methods and a new rearing facility on the Sacramento River (Livingston Stone NFH) alleviated concerns about the program's ability to supplement the natural winter chinook salmon population.

Steelhead Trout
Steelhead trout have been propagated at Coleman NFH every year since 1947.

1.15 Expected duration of program

Fall Chinook Salmon
Coleman NFH's fall chinook salmon propagation program is considered to be permanent. The primary goal of the fall chinook propagation program is mitigation for fall chinook spawning and early-rearing habitat permanently lost by the construction of Shasta Dam.

Late-fall Chinook Salmon
Coleman NFH's late-fall chinook salmon propagation program is considered to be permanent. The primary goal of the late-fall chinook propagation program is mitigation for Shasta Dam which permanently blocked large portions late-fall chinook spawning and rearing habitat.

Winter Chinook Salmon
Artificial propagation of winter chinook salmon at Livingston Stone NFH is a temporary measure to assist in the recovery of natural winter chinook salmon in the upper Sacramento River. Artificial propagation of winter chinook salmon is expected to cease when the naturally-spawning population of winter chinook salmon is ≥10,000 females, with a growth rate (geometric mean cohort replacement rate) ≥1 for at least 13 years (Botsford and Brittnacher 1998). Fulfillment of these de-listing criteria is considered to provide reasonable assurance that the species would no longer be in imminent danger of extinction.

The National Marine Fisheries Service (1997) recommends that the captive broodstock program should "continue to be assessed for its efficacy and necessity in recovering winter-run chinook, and the program should be terminated when the run-size of the wild population reaches 1,000 per year on a sustained basis" (Chapter 5, page 60). Originally, this program was funded for ten years (1991 - 2001). It is currently authorized under the Service's Section 10 Enhancement Permit (see Section 2.3 on ESA Permits), but is in the process of being re-assessed.

Steelhead Trout
Considered collectively, the steelhead trout propagation program at Coleman NFH is permanent, however, certain elements of the program may have limited duration. Anticipated duration of the different aspects of the Coleman NFH steelhead trout program are as follows:

> *mitigation* - Since the beginning of the Coleman NFH steelhead trout propagation program in 1947, the primary goal has been to mitigate for spawning and rearing habitat that was permanently lost as a result of the construction of Shasta Dam. This mitigation responsibility of the Federal government is considered to be essentially permanent in duration.
>
> *recovery* - A new goal the Coleman NFH steelhead trout program is to assist in the recovery of a naturally reproducing populations. Currently, hatchery-origin steelhead trout are released above the Coleman barrier weir to spawn naturally in upper Battle. Furthermore, the

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Service proposes to collect natural-origin broodstock from Battle Creek beginning in 2001-2002 to use as hatchery broodstock. The Service proposes to manage the Battle Creek steelhead trout population as an integrated hatchery and natural population on a permanent basis (i.e., annual releases of hatchery-origin steelhead trout to spawn naturally in upper Battle Creek and annual collection of natural-origin steelhead trout for broodstock). The Service intends to manage the Battle Creek steelhead trout population in this way to reduce potential ecological risks associated with a reduced and fluctuating natural population (e.g., by increasing the effective population size and providing increased and stable numbers of natural spawners to Battle Creek) and also to reduce potential genetic risks associated with hatchery propagation (e.g., loss of variability and domestication). The Service will investigate additional uses of Coleman NFH steelhead trout for future recovery-oriented actions in other locations of the upper Sacramento River system. Criteria for phasing out steelhead trout recovery programs in specific locations will be developed on a case-by-case basis.

1.16 Watersheds targeted by program

Fall Chinook Salmon

Fall chinook salmon propagated at Coleman NFH return primarily to Battle Creek (PSC Inland Location code: 6FCSABAT). Additionally, a small proportion of hatchery-origin fall chinook adults unavoidably stray and spawn with the naturally-spawning fall chinook salmon population in the upper Sacramento River (PSC Inland Location code: 6FCSASAF)

Late-fall Chinook Salmon

Late-fall chinook salmon propagated at Coleman NFH return primarily to Battle Creek (PSC Inland Location code: 6FCSABAT). Additionally, a small proportion of hatchery-origin late-fall chinook adults stray and spawn with the natural population in the upper Sacramento River. Most of these fish spawn north of the city of Red Bluff (PSC Inland Location code: 6FCSASAF ABRB).

Winter Chinook Salmon

The winter chinook salmon propagation program at Livingston Stone NFH is targeted at supplementing the naturally spawning population of winter chinook salmon in the upper Sacramento River. Most of the natural-origin fish spawn north of the city of Red Bluff (PSC Inland Location code: 6FCSASAF ABRB).

Steelhead Trout

Steelhead trout propagated at Coleman NFH return primarily to Battle Creek (PSC Inland Location code: 6FCSABAT). Additionally, a small proportion of hatchery-origin adults stray into the upper Sacramento River and it's tributaries (PSC Inland Location code: 6FCSASAF).

1.17 Alternative actions considered for attaining program goals, and reasons why those actions are not being proposed

Since the construction of Shasta Dam, artificial production has been considered an essential component of the Service's strategy to mitigate for negative effects on natural Sacramento River salmonid populations. The creation of Shasta Dam on the Sacramento River permanently blocked approximately 187 miles of anadromous fish spawning and rearing habitats, reducing the estimated carrying capacity of that aquatic ecosystem to support chinook salmon and steelhead trout by approximately 50%. Barring the removal of Shasta Dam or the creation of new (artificial) salmonid spawning habitats below Shasta Dam, federal mitigation responsibilities cannot be fully met without artificial production.

At the time Shasta Dam was being constructed, an investigation was underway to determine the dam's full effects. A report entitled "An investigation of fish salvage problems in relation to Shasta Dam" was released in 1940. This report is also known as "Special Scientific Report Number 10." The report presented three major plans, and a minor fourth plan to salvage salmon runs to the upper Sacramento River. The three main plans were: 1) The Stillwater Plan; 2) The Battle Creek Plan; and 3) The Sacramento River Natural Spawning Plan (Hanson et al. 1940). The final adoption of a plan resulted in the combination of various components of the original plans. The adopted plan (entitled: The Sacramento River, Battle Creek, and Deer Creek Salvage Plan) is called "the Shasta Salvage Plan." A complete description of the evolution of "The Salvage Plan," which justified the construction of Coleman NFH on Battle Creek, is described in detail in Black (1999, also see Section 1.8 and Section 2.2 of this document).

Coleman NFH was created in 1942 to partially mitigate for fishery losses resulting from the isolation of spawning and rearing habitats above the Shasta Dam. Commercial and recreational fisheries serve an important role in the region's social, cultural, and economic well-being. Coleman NFH provides an important tool for augmenting commercial and sportfishing harvest for fall and late-fall chinook salmon. Coleman and Livingston Stone NFH's also provide important tools necessary to maintain genetic diversity, prevent extinction, and assist in the recovery of declining and imperiled salmonid populations.

While fish hatcheries are an integral component of the current federal mitigation strategy in the upper Sacramento River, they are not the sole remedy for mitigating negative effects on salmonid populations. Restoration of aquatic ecosystems and recovery of at-risk species are the Service's priorities for the National Fish Hatchery System. Additional actions to complement hatchery production programs include alignment of hatchery programs with the Central Valley Project Improvement Act (CVPIA), Anadromous Fish Restoration Program (AFRP), and CALFED Ecosystem Restoration Program (ERP). The Service is continually modifying artificial propagation programs at Coleman and Livingston Stone NFH's, incorporating strategies designed to promote the recovery of healthy, naturally-spawning populations. During recent years, substantial changes to hatchery facilities and operations have occurred at Coleman NFH to integrate the hatchery with the Battle Creek Restoration Process. Integrating Coleman NFH operations with the Battle Creek Restoration Process is a coordinated strategy that includes habitat restoration (flow improvements), fish passage improvements, intake screening, and fishery monitoring (see Section 3 for a more complete discussion of the relationship between Coleman NFH and Battle Creek Restoration).

PROGRAM EFFECTS ON SALMONID POPULATIONS

The Coleman NFH and its substation at Shasta Dam, the Livingston Stone NFH, propagate three runs of chinook salmon and steelhead trout. Fall and late-fall chinook salmon and steelhead trout are propagated at Coleman NFH. Winter chinook salmon are propagated exclusively at the Livingston Stone NFH. All stocks propagated at Coleman NFH and Livingston Stone NFH are managed to be integrated with naturally-spawning populations, and all hatchery stocks are included within the ESU of their respective natural populations. Winter chinook salmon are currently the only ESA-listed hatchery stock propagated at either Coleman NFH or Livingston Stone NFH.

2.1 History of listing determinations

Winter Chinook Salmon

Natural- and hatchery-origin winter chinook salmon from the Sacramento River are included in the Central Valley ESU for the species and are state and federally listed as endangered. NMFS listed these salmon as threatened under the emergency listing procedures for the ESA (16 U.S.C.R. 1531-1543) on August 4, 1989 (54 Federal Register {FR} 32085). A proposed rule to add winter chinook salmon to the list of threatened species beyond expiration of the emergency rule was published by the NMFS on March 20, 1990 (55 FR 10260). Winter chinook salmon were formally added to the list of federally threatened species by final rule on November 5, 1990 (55 FR 46515), and they were listed as a federally endangered species on January 4, 1994 (59 FR 440). Critical habitat for winter chinook salmon has been designated from Keswick Dam (Sacramento River mile 302) to the Golden Gate Bridge (58 FR 33212; June 16, 1993). Winter chinook salmon have been listed as endangered under the CESA since September 22, 1989 (California Code of Regulations, Title XIV, Section 670.5).

Spring Chinook Salmon

Central Valley spring chinook salmon are state and federally listed as a threatened species. On March 9, 1998, the NMFS published a proposed rule to list Central Valley spring chinook salmon as endangered under the ESA (63 FR 11482). On March 24, 1999, the NMFS extended the final deadline for a listing determination for Central Valley spring chinook until September 9, 1999 (63 FR 14329). The NMFS published the final rule to declare Central Valley spring chinook salmon a threatened species on September 16, 1999 (64 FR 50393). Critical habitat for spring chinook salmon was designated on February 16, 2000 and includes "...all accessible reaches of all rivers" within the range of the Central Valley spring chinook ESU (65 FR 7764). Central Valley spring chinook salmon have been listed as threatened under CESA since February 5, 1999 (California Code of Regulations, Title 14, Section 670.5). Central Valley spring chinook salmon are not currently propagated by the Service or USBR.

Fall and Late-fall Chinook Salmon
Central Valley fall and late-fall chinook salmon are currently identified as candidate species under the ESA, and hatchery- and natural-origin stocks for both species are included in their respective Central Valley ESU's. On March 9, 1998, NMFS published a proposed rule to list Central Valley fall and late-fall chinook salmon as threatened under the ESA (63 FR 11482). On March 24, 1999, NMFS deferred a final listing decision for Central Valley fall and late-fall chinook salmon for six months (63 FR 14329). On September 16, 1999, NMFS published a final decision to not list Central Valley fall and late-fall chinook salmon as threatened under the ESA, but instead declared them as candidate species (64 FR 50394). As candidate species, the NMFS will closely monitor and reevaluate the status of Central Valley fall and late-fall chinook salmon as new information becomes available to determine whether listing may be warranted. Central Valley fall and late-fall chinook salmon are currently not listed under the CESA.

Steelhead Trout
Central Valley steelhead trout are federally listed as a threatened species. On August 9, 1996, the NMFS published a proposed rule to list Central Valley steelhead trout as endangered under the ESA of 1973 (61 FR 41541). On August 18, 1997, NMFS deferred a final listing decision for Central Valley steelhead trout for six months, citing substantial scientific disagreements concerning the geographical extent of the Central Valley ESU. On March 19, 1998, the NMFS published a final rule (63 FR 13347) to list California's Central Valley steelhead trout as threatened under the ESA. Critical habitat has also been established for steelhead trout (63 FR 7764; February 16, 2000), and includes Battle Creek. Currently, Steelhead trout are not listed under the CESA.

2.2 List all ESA permits or authorizations in hand for the hatchery program.

Coleman and Livingston Stone National Fish Hatcheries
Legislative authorizations for the Coleman NFH do not identify the hatchery by name but, rather, authorities for the Coleman NFH fall into the realm of "defacto" authorizations. The Coleman NFH is authorized as part of the overall CVP as a mitigation[1] facility. It is the policy of the Service to seek and mitigate losses of fish, wildlife, their habitats and uses thereof from land and water developments. Coleman NFH was created to partially compensate for fishery losses resulting from the construction of Shasta Dam. Mitigation policies and objectives of the Service are described in the U.S. Fish and Wildlife Service Mitigation Policy dated January 23, 1981 (46

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[1] The Service has adopted the definition of "mitigation", as presented in the National Environmental Policy Act (NEPA) regulations, to include: "(a) avoiding the impact altogether by not taking a certain action or parts of action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and, (e) compensating for the impact by replacing or providing substitute resources or environments." (40 FR 1508).

FR 7644). As part of the overall CVP, Coleman NFH is authorized through the following documents and legislation:

The Shasta Dam on the upper Sacramento River was constructed by the United States Government, under authority of the *Reclamation Act of June 17, 1902*. The Shasta Dam and power plant are the principal features of the CVP (16 U.S. C 695d-695j), a series of dams, diversions, and canals constructed for the improvement of Central Valley navigation, flood control, irrigation, salinity control, and electric power generation. The CVP was first established under the authority of the *Emergency Relief Appropriations Act* (Chapter 48, April 8, 1935; 49 Stat. 115). *The First Deficiency Appropriation Act* of 1936 (Chapter 689; June 22; 74 Stat. 1622) formally authorized federal funds for the CVP by name. The CVP was subsequently reauthorized by *The River and Harbor Act* (Chapter 832; August 26, 1937; 50 Stat 844, 850) and the following additional statutes:

Chapter 895; October 17, 1940; 54 Stat. 1198 and 1199
Chapter 690; October 19, 1949; 63 Stat 852
Chapter 1047; September 26, 1950; 64 Stat 1036

Public Law 674 (August 27, 1954; 68 Stat. 879) declared use of CVP water for fish and wildlife as a project purpose in addition to all other previously stated purposes. Public Law 95-616 (November 8, 1978; Stat. 3115) amended the 1954 Act to guarantee the delivery of 3000 acre-feet of water each fall and 4000 acre-feet of water each summer to aid salmonid populations. The *Reclamation Projects Authorization and Adjustment Act* of 1992 (Public Law 102-575; October 30, 1992; 106 Stat. 4600), also called the CVPIA, amended the CVP to address the project impacts on fish and wildlife resources including provisions to protect, restore, and enhance fish and wildlife and their habitats.

In 1941, construction of the Shasta Dam permanently blocked salmon and steelhead trout from accessing their historic principal spawning and rearing areas in the Sacramento, Pit, and McCloud rivers and their tributaries. The federal government assumed responsibility for preserving the runs of migratory salmon and steelhead blocked by the Shasta Dam. Biological investigations of the effects of the Shasta Dam on anadromous fisheries were initiated at the time when dam construction began. Fisheries investigations were financed by the USBR, under the supervision of the U.S. Bureau of Fisheries (now U.S. Fish and Wildlife Service), and under the authority of the *Act of March 10, 1934* entitled an "Act to promote the conservation of wildlife, fish, game, and for other purposes." Section 3 of that act authorized the "Bureau of Fisheries to make surveys of the wild-life resources of the public domain, or of any lands owned or leased by the Government, to conduct such investigations as may be necessary for the development of a program for the maintenance of an adequate supply of wild-life in these areas...." The three primary fishery salvage investigations in relation to Shasta Dam were:

1) "An Investigation of Fish-salvage Problems in Relation to Shasta Dam," Special Scientific Report No. 10 by H. Hanson, Bureau of Reclamation, O. Smith and P. Needham, Bureau of Fisheries, 1940.

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The authors stated "Responsibility for saving the runs of migratory salmon and steelhead which will be blocked by Shasta Dam has been assumed by the Government...." This report describes three plans which contain components of artificial and natural propagation for salvaging runs of Sacramento River salmon.

2) "Report of the Board of Consultants on the Fish Problems of the Upper Sacramento River," by R. Calkins, W. Durand, and W. Rich, July, 1940.

This report recommended the salvage plan of Hanson, Smith, and Needham with the recommendation of "continuing study of the results of artificial propagation." Construction of a fish hatchery to partially compensate for the loss of salmon caused by the Shasta Dam.

3) "Supplementary Report on Investigations of Fish-salvage Problems in Relation to Shasta Dam," Special Scientific Report No. 26 by P. Needham, H. Hanson, and L. Parker, June 943.

This report updated the position of "the status plan recommended by the Board of Consultants and accepted by the U.S. Bureau of Reclamation" and outlines the facilities required to carry out this plan, including the construction of the Coleman NFH.

Additional descriptions of roles and responsibilities of Coleman and Livingston Stone NFH's are contained within the following authorities:

Fish and Wildlife Coordination Act (March 10, 1934; 48 Stat. 401)
Fish and Wildlife Act of 1956 (August 8, 1956; 70 Stat. 1119)
Endangered Species Act of 1973 (December 28, 1973; 87 Stat. 884-903)
Reclamation Projects Authorization and Adjustment Act of 1992 (Central Valley Project Improvement Act) (October 30, 1992; 106 Stat. 4714-4731)

The Bureau of Reclamation assumed the responsibility for funding the construction and early fish culture operations at the Coleman NFH. Custody and fiscal responsibility of the Coleman NFH were subsequently transferred to the Service upon finding that "salmon runs above Shasta Dam appear to have become established below the dam in numbers equal to the numbers existing before the dam was built" (Memorandum of Agreement dated September 21, 1948). On January 11, 1991, an audit report by the Inspector General concluded that mitigation costs associated with fishery damages attributable to USBR water projects were reimbursable and could be recovered from project beneficiaries. In that audit, the Coleman NFH was affirmed to be part of the overall CVP. Two years later, on March 19, 1993, an Interagency Agreement Between Bureau of Reclamation and Fish and Wildlife Service Concerning Coleman National Fish Hatchery resolved that future financial responsibilities for Coleman NFH operations, maintenance, and evaluation were re-assumed by the USBR, to be properly allocated among CVP beneficiaries. This Agreement superceded all previous agreements made between the USBR and the Service regarding the Coleman NFH.

2.3 ESA Permits

Section 7 Permitting History:

Programs:	Artificial propagation of non-listed hatchery-origin fall and late-fall chinook salmon and steelhead trout
Current Permit:	Section 7 Biological Opinion covering propagation of non-listed salmonids at Coleman NFH
Issue Date:	February 18, 1999
Expiration Date:	December 31, 1999, the Service is currently operating under an extension of this permit

In accordance with incidental take requirements of the ESA, the Service initially submitted a Section 7(a)(2) Biological Assessment covering effects of artificial production of non-listed stocks at Coleman NFH on endangered winter chinook salmon in November 1993 (USFWS 1993). The resultant Biological Opinion issued by NMFS on February 14, 1994, concluded the operation of Coleman NFH for non-listed salmonids "...is not likely to jeopardize the continued existence of winter-run chinook salmon or result in the destruction or adverse modification of its critical habitat" (NMFS 1994). This Biological Opinion expired on 31 December 1996.

The Service submitted another Biological Assessment in October 1996 (USFWS 1996a) and was granted non-jeopardy coverage for hatchery programs for an additional two years, through December 31, 1998 (NMFS 1996a). At that time, NMFS requested the Service initiate a comprehensive review of all Coleman NFH propagation programs prior to the expiration of that permit (Letter from Hilda Diaz-Soltero, NMFS Regional Director, to Mike Spear, USFWS Regional Director, dated December 23, 1996). The programmatic review was to re-examine the future role of Coleman NFH in helping to restore declining stocks of salmonids in the Central Valley, given the likelihood that steelhead, spring chinook, and other chinook populations in the Central Valley would continue to decline and become listed.

The Service initiated the Coleman NFH Re-evaluation Process during 1998. Due to the large scope of this project, however, substantial work remained when the Service's Biological Opinion was due to expire on December 31, 1998. On October 16, 1998, the Service submitted a project description and impact assessment to NMFS and requested to amend the 1996 Biological Opinion, extending Section 7 coverage for the expected duration of the Coleman NFH Re-evaluation Process. Short-term non-jeopardy coverage for hatchery programs was provided through December 1999 by the NMFS Biological Opinion dated February 18, 1999.

In late 1999, the Service re-initiated Section 7 consultation with NMFS in anticipation of the expiration of the existing Biological Opinion and the recent listing (September 1999) of spring chinook salmon. As part of this consultation, submission of a project description and Biological Assessment (BA) was expected by NMFS prior to March 8, 2000. However, completion of the Coleman/Livingston Stone BA has been delayed for a variety of reasons including the lengthy public re-evaluation process and incorporation of the highly-detailed format of the new Hatchery and Genetic Management Plan (HGMP). NMFS supported an extension of the initial timeline to

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allow information generated during the re-evaluation process to be incorporated and reformatting of the BA using the HGMP format as a template.

This BA incorporates and addresses comments and concerns generated through stakeholder-participation in the Coleman NFH Re-evaluation Process. Substantial progress was made on the Coleman NFH Re-evaluation Process during 1999-2000. Compilation and analysis of historical hatchery operations, analysis of fishery contribution rates, and analysis of potential impacts of hatchery production programs are largely complete, and much of the information generated through these analyses has been included as part of this Section 7 permit application. The determination of fishery losses resulting from Shasta Dam has also received considerable effort, and will continue to be investigated to determine and formalize federal mitigation responsibilities, including that portion to be mitigated by Coleman NFH. Lastly, a total of 56 management and operational alternatives were suggested to minimize potential negative impacts of hatchery propagation programs on natural stocks. Further development and analyses of these alternatives is in progress. Information generated through analyses of these alternatives may be used to modify future activities at Coleman NFH to minimize potential negative effects on natural stocks.

Section 10 Permitting History:

Program:	Artificial propagation, enhancement, and associated monitoring projects for ESA-listed hatchery-origin winter chinook salmon
Current Permit:	Section 10 Enhancement Permit (No. 1,027) authorizing the winter chinook salmon propagation and captive broodstock programs, and associated monitoring projects.
Issue Date:	January 31, 1997
Expiration Date:	July 31, 2001.

The Service's initial permit application, requesting take of ESA-listed winter chinook salmon under Section 10 of the ESA, was submitted to NMFS on July 13, 1990 (USFWS 1990). Both the winter chinook salmon captive propagation and captive broodstock programs subsequently received coverage under the Section 10 permit # 747, dated August 8, 1991 (NMFS 1991). This permit authorized the Service's directed-take activities of winter chinook for both scientific and enhancement purposes. Because of the complexity and rapid evolution of these programs, this permit was modified several times over the following six years.

In 1995, the discovery of two problems necessitated significant alterations to the Service's winter chinook propagation program. Monitoring conducted by the Service's Northern Central Valley Fish and Wildlife Office (now the Red Bluff Fish and Wildlife Office [RBFWO]) revealed that adult winter chinook salmon were returning to Battle Creek and not the mainstem Sacramento River, the intended target of the supplementation program (USFWS 1996b). Additional data provided genetic evidence suggesting the interbreeding of winter chinook salmon with spring chinook salmon in the hatchery population (Hedgecock et al. 1995). In combination, these raised questions as to the program's ability to: 1) supplement the natural population in the mainstem Sacramento River; and, 2) maintain the genetic integrity of the ESA-listed species.

In light of the above findings, and in conjunction with a Section 10 permit extension, NMFS imposed a temporary (90-day) moratorium on the capture of adult winter chinook salmon in the mainstem Sacramento River prior to the 1995-1996 trapping season (i.e., December-August). In a series of meetings held during the week of January 8, 1996, the Service announced that the verification of these findings and analyses of potential solutions would be examined during 1996. However, as the problems were not likely to be resolved early in the year, the Service proposed to extend the moratorium on the capture of adult Sacramento River winter chinook salmon for the entire year (1996). Following this announcement, the NMFS further extended permit #747 until November 30, 1996.

During October 1996, the Service submitted a Section 10 permit application to NMFS, again proposing to extend the moratorium on the capture of naturally-produced winter chinook adults for another year (through 1997), or until concerns about imprinting and genetic identification of broodstock were throughly addressed. NMFS responded with another short-term extension to permit #747 and, shortly thereafter, issued a new ESA Section 10 permit (#1,027; 31 January 1997) to completely replace permit #747 (NMFS 1997).

On February 20, 1998 the Service submitted to NMFS a Section 10 permit supplement requesting re-authorization of the winter chinook propagation program, contingent upon addressing imprinting and genetic concerns. An addendum to the permit supplement was subsequently submitted to NMFS on June 30, 1998. The addendum provided information on advances made in genetic identification of winter chinook salmon and the completion of Livingston Stone NFH, built to rear and imprint winter chinook salmon to the mainstem Sacramento River. The Service's winter chinook salmon propagation program was fully re-authorized by NMFS on March 13, 1998.

All information submitted to NMFS (i.e., permit applications and permit supplements) were also provided to CDFG to satisfy CESA permitting requirements. Based on that information, Memoranda of Understanding (MOU's) were developed between CDFG and the Service for the winter chinook artificial propagation and captive broodstock programs. The Service's winter chinook salmon propagation program was re-authorized by CDFG on March 11, 1998.

2.4 Description of ESA-listed salmonid populations affected by the program

Information presented below summarizes biological information and life history characteristics of ESA-listed and non-listed salmonid populations potentially affected by artificial propagation programs at Coleman and Livingston Stone NFH's. General information is presented on geographic distribution and life history characteristics of natural stocks co-occurring with chinook salmon and steelhead trout from Coleman NFH. Greater detail of biological and environmental information can be found for ESA-listed stocks of winter chinook salmon in NMFS (1997), for spring chinook salmon in CDFG (1998) and Myers et al. (1998), and for steelhead trout in Busby et al. (1996) and McEwan and Jackson (1996). Additional life history and biological information on ESA-candidate species fall and late-fall chinook salmon can be found in Myers et al. (1998).

Winter Chinook Salmon

Since the construction of Shasta Dam, spawning habitat for winter chinook salmon has been limited to the upper Sacramento River, primarily between Shasta Dam and Red Bluff (Hallock and Fisher 1985, NMFS 1997). Migrating winter chinook salmon generally arrive at RBDD between mid-December and early August. Most migrating winter chinook adults pass RBDD between January and May, with numbers peaking in March. Winter chinook spawning occurs from mid-April through mid-August, with most spawning activity occurring in May and June. Hallock and Fisher (1985) estimated age structure of spawning winter chinook as follows: 25% age-2, 67% age-3, and 8% age-4. However, this study only included three brood years (one generation) of spawning fish. Fisher (1994) later reported that most females mature at age-3 (1% age-2, 91% age-3, and 8% age-4). Information on age structure of more recent brood years are in preparation, using data collected from adults at the Keswick fish trap.

Size and sex ratio data for spawning winter chinook salmon are available for adults captured during 1998, 1999, and 2000 at the Battle Creek barrier weir, RBDD fish trap, and Keswick Dam fish trap (Table 2-1). Adult males ranged between 391 and 958 mm fork length (FL), and females ranged between 523 and 875 mm FL. Approximately 6% of female and 30% of male winter chinook salmon collected were less than 620 mm (USFWS, RBFWO, unpublished data); this length is roughly associated with age-2 spawners. Female winter chinook outnumbered males in two of three years, with an average male-to-female sex ratio 0.8 to 1.

Table 2-1. Size ranges, means, and sex ratios of spawning winter chinook salmon captured at Coleman barrier weir, Red Bluff Diversion Dam, and Keswick Dam for 1998, 1999, and 2000. [a,b]

Brood-year	Males				Females				Sex Ratio[c] (♂ to ♀)
		Fork length (mm)				Fork length (mm)			
	Number	Min	Max	Mean	Number	Min	Max	Mean	
1998	47	582	952	733	69	523	781	674	0.7 to 1
1999	14	492	772	578	10	610	782	678	1.4 to 1
2000	50	391	958	680	62	681	875	764	0.8 to 1
Overall	111	391	958	690	141	523	875	714	0.8 to 1

a Source: U.S. Fish and Wildlife Service unpublished data.

b Winter chinook salmon were identified through genetic analyses completed by Bodega Marine Laboratory, University of California Davis, Bodega, California.

c Five fish (3 from 1998, and 1 each from 1999 and 2000) were not classified according to sex and were excluded.

Winter chinook eggs incubate and hatch in about two months (more-or-less depending on water temperatures). Juveniles emerge between the end of June and mid-October (Vogel and Marine 1991). Juvenile winter chinook salmon generally emigrate between August and April, with peak emigration rates in September (Johnson and Martin 1997, USFWS, RBFWO unpublished data). Juvenile winter chinook salmon are estimated to be 120 mm FL at the time of entering saltwater (Fisher 1994).

Spring Chinook Salmon

Current spawning habitats for spring chinook salmon are restricted to the upper Sacramento River, below Keswick Dam, and larger east-side tributaries including Mill, Deer, and Butte creeks. Migration of adult spring chinook salmon in the upper Sacramento River begins in late-March. Historical accounts suggest that spring chinook salmon migration continued until October, peaking July through September. However, recent data for spring chinook populations in Mill and Deer creeks show adult migrations occurring primarily from March through June, peaking during the month of May (Colleen Harvey-Arrison, CDFG, Red Bluff, pers. comm.). Changes in timing of migration apparently occurred after the construction of Shasta Dam, and indicate possible hybridization with fall chinook salmon (CDFG 1998). Spring chinook spawning occurs from mid-August through October and peaks in late September. Data on age and sex ratios of upper Sacramento River spring chinook spawners are not currently available.

Age at emigration varies among juvenile spring chinook salmon; they have been captured emigrating as fry, fingerlings, and yearlings (CDFG 1998, USFWS, RBFWO, unpublished data). Newly-emerged spring chinook fry begin migrating past RBDD in November. Emigration continues through April, with the largest numbers of juveniles passing RBDD as fry in December and January (Johnson and Martin 1997). Estimated size of spring chinook salmon is 80 mm FL at the time of saltwater entry (Fisher 1994).

Steelhead Trout

Life history characteristics for steelhead trout are highly variable. Adult steelhead trout pass RBDD throughout the year. Most of the migrating adults arrive between the end of August and the end of November, with peak numbers passing in late September and early October. Spawning occurs between late December and early May, peaking in February (Hallock 1989, Busby et al. 1996).

Hallock (1989) reports age structure of naturally-spawning steelhead as follows: 17% age-2, 41% age-3, 33% age-4, 6% age-5, and 2% age-6. Most steelhead trout spawn once then die, but limited repeat spawning does occur, mostly among females. Analysis of scale data indicated 83% were first-time spawners, 14% were second-time spawners, 2% were spawning for the third time, and 1% spawned for the fourth time (Hallock 1989). Sex ratios for naturally-spawning populations of steelhead trout in the Sacramento River are not available, but overall sex ratio of steelhead trout along the west coast of the US is thought to be 1 to 1 (Pauley et al. 1986).

Steelhead trout eggs generally hatch in four to seven weeks, and fry emerge one to two weeks after hatching (Pauley et al. 1986). Juvenile steelhead trout may emigrate soon after emergence, or spend one to two years in freshwater before their seaward migration. Hallock (1989) reported a small percentage of steelhead trout rear for three years in freshwater before smolting. Most steelhead trout disperse downstream past the RBDD shortly after emergence from the gravels (USFWS, unpublished data). Newly-emerged steelhead trout fry emigrate from the upper Sacramento River in two temporal peaks annually. Steelhead trout fry (~50 mm) typically begin to pass RBDD in February and downstream movement continues through August. A second, distinct peak of steelhead trout fry typically begins to pass RBDD in early-July and continues through November (Johnson and Martin 1997, USFWS RBFWO, unpublished data). Based on ATPase activity, steelhead trout at Coleman NFH are physiologically ready to transition from freshwater to marine environments at approximately 160 mm FL (USFWS CA-NV FHC, unpublished data).

2.5 Description of non-listed salmonid populations affected by the program.

Fall and late-fall chinook salmon are not listed under the ESA or CESA at present. Natural populations of these Central Valley stocks are identified as candidates for listing (September 16, 1999, 50 FR 50394).

Fall Chinook Salmon

Fall chinook are the most abundant run of salmon in the Central Valley. Migrating adult fall chinook salmon begin passing RBDD in late July. Their migration continues through late November, with peak numbers arriving in the upper Sacramento River in October. Spawning occurs between October and December, with peak spawning in November (Vogel and Marine 1991). From 1996 to 1999, sex ratios of naturally spawning fall chinook salmon averaged 0.86 males to each female (range 0.6 to 1 males to 1 female). Fork lengths of females ranged from 450 to 1070 mm FL, with an average of 800 mm. Fall chinook males ranged between 350 and 1130 mm FL, and averaged 812 mm (Snider et al. 1997, 1998, 1999a, 2000).

Juvenile fall chinook salmon generally emigrate as fry. Fall chinook emigration occurs between the months of December and June, with a peak in January (Johnson and Martin 1997, Martin et al. 2000). Fall chinook are estimated to be 80 mm FL upon entry to saltwater (Fisher 1994).

Late-fall Chinook Salmon

Data on naturally-spawning late-fall chinook salmon are sparse, primarily because environmental conditions (e.g., high flows and turbid water) during migration and spawning make data collection difficult. Migrating adults begin passing RBDD in late October. Their migration continues through March, with peak numbers arriving in the upper Sacramento River in December and January. Late-fall chinook spawning occurs between January and April, with peak spawning in February and March (Vogel and Marine 1991).

In the late-fall chinook upper Sacramento River escapement survey, Snider et al. (1999b) observed adult females ranging from 520 to 1020 mm FL (mean 821), and males ranging from

340 to 1050 mm FL (mean 924). The sex ratio of carcasses recovered was 0.5 males for each female. Data collected from late-fall chinook salmon trapped at Keswick Dam in 1995 and 1996 show a sex ratio of 0.7 males to 1 female (N = 205) (USFWS RBFWO unpublished data). Age structure of the naturally-spawning population of late-fall chinook salmon is currently unknown.

Juveniles emigrate past RBDD from April through January, with higher numbers in April and May (Johnson and Martin 1997). Late-fall chinook salmon have been estimated to be 160 mm FL upon entering saltwater (Fisher 1994).

2.6 ESA-listed and non-listed populations that will be directly affected by the program.

Winter Chinook Salmon (Endangered)
The Sacramento River winter chinook salmon ESU will be directly affected by the Livingston Stone NFH artificial propagation program. Natural-origin winter chinook salmon are intended to be integrated with returning hatchery-origin fish as part of this program, and returning hatchery-origin adults are intended to spawn with the naturally-spawning population of winter chinook salmon in the upper Sacramento River.

Steelhead Trout (Threatened)
The Central Valley steelhead trout ESU will be directly affected by the artificial propagation program at Coleman NFH. Natural-origin adult steelhead returning to Battle Creek are integrated with the hatchery-origin steelhead for the artificial propagation program. Excess hatchery-origin steelhead that return to Coleman NFH are currently passed above the barrier weir, allowing them to spawn naturally in the upper sections of Battle Creek. Additionally, a small percentage of hatchery steelhead stray, spawning with other natural populations of steelhead trout in the mainstem Sacramento River and other tributaries.

Fall and Late-Fall Chinook Salmon (Candidate Species)
Fall and late-fall chinook salmon populations will also be directly affected by fish propagation programs at Coleman NFH. Fall and late-fall chinook salmon propagation programs at Coleman NFH are managed to integrate hatchery stocks with the naturally-spawning populations in Battle Creek and the mainstem Sacramento River. Integration between hatchery and natural stocks is conducted to decrease domestication, inbreeding, and genetic drift in hatchery populations. To integrate hatchery and natural populations of fall chinook, natural-origin adults are collected in Battle Creek and incorporated as hatchery broodstock. Hatchery-origin fall chinook adults also spawn with natural-origin fish below the barrier weir in Battle Creek and in the mainstem Sacramento River. To integrate hatchery and natural populations of late-fall chinook, natural-origin adults will be collected from the mainstem Sacramento River and used as hatchery broodstock. Additionally, an unknown, but presumably small, percentage of hatchery late-fall chinook salmon spawn naturally in Battle Creek and the mainstem Sacramento River.

2.7 ESA-listed populations that may be incidentally affected by the program.

In addition to being directly affected, the ESA-listed species identified above (winter chinook salmon and steelhead trout) and candidate species (fall and late-fall chinook salmon) may also be incidentally affected by artificial propagation programs at Coleman NFH and Livingston Stone NFH. Spring chinook salmon (listed as threatened) may also be incidentally affected by artificial propagation programs at Coleman NFH and Livingston Stone NFH.

2.8 Status of ESA-listed salmonid populations affected by the program

The following descriptions of status of ESA-listed chinook salmon populations in the Central Valley have been extracted largely from the NMFS status review (Myers et al. 1998) and for steelhead trout from the NMFS status review (Busby et al. 1996).

Winter Chinook Salmon

Historically, winter chinook salmon were abundant and comprised of populations in the McCloud, Pit, Little Sacramento, and Calveras rivers. Most of these populations have been isolated from historic spawning and rearing habitats by the construction of Shasta Dam. Currently, the ESU is mostly confined to the mainstem Sacramento River below Keswick Dam, and a small remnant population may also exist in Battle Creek. Population estimates for winter chinook salmon are determined by counting passage through the fish ladders at RBDD and, since 1996 by conducting a carcass survey using mark-and-recapture methods. Based on passage estimates at RBDD, the Sacramento River winter chinook salmon population reached a low abundance in 1994 when an estimated 189 adults passed above RBDD (Table 2-2). From 1967 through the early 1990's, the Sacramento River winter chinook salmon population declined at an average rate of 18% per year, or roughly 50% per generation. Since the early 1990's, the winter chinook salmon population has shown signs of increasing abundance. The average spawner abundance for winter chinook salmon from 1987 - 1999 is 1,273. Recent estimates for spawner replacement ratios are as follows: 1.2 to 1 (1992-1995), 2.8 to 1 (1993-1996), 4.4 to 1 (1994-1997), 1.9 to 1 (1995-1998), 3.2 to 1 (1996-1999), and 1.6 to 1 (1997-2000) (USFWS RBFWO unpublished data). Estimated number of natural-origin winter chinook juveniles emigrating past the RBDD on the upper Sacramento River from 1995 to 1999 averaged over 1.9 million, ranging between 384,146 and 4,628,597 (Martin et al. 2000).

An estimate of a critical population threshold is not presently available for winter chinook salmon. A viable population estimate is also unavailable; however, the NMFS (1997) has developed delisting criteria which include a mean annual spawning population estimate of 10,000 females over 13 years. This estimate does not conform to the NMFS's definition of a "viable" population because the risk of extinction was evaluated for 50 years instead of 100 (McElhany et al. 2000).

Spring Chinook Salmon

Spring chinook salmon were once the predominant run in the Central Valley. Present day abundance of spring chinook has declined dramatically from historical levels. Commercial harvest data comparing average catch from 1916 through 1949 and 1950 through 1957 showed a

90% reduction in spring chinook salmon harvest over that time period (Skinner 1958). Dam construction and habitat degradation have eliminated spring chinook populations from the entire San Joaquin River Basin and from many tributaries to the Sacramento River Basin. Estimated spawner escapement for the Sacramento River basin population of spring chinook salmon averaged 11,155 over the last 13 years, but yearly estimates ranged widely from just over 3,000 spawners to over 31,000 (Table 2-2). There are only a few isolated, naturally-spawning populations remaining and these all have relatively low abundances (typically <1000) (Yoshiyama et al. 1998). Streams that support wild, persistent, and long-term documented populations of spring chinook salmon are Mill, Deer, and Butte Creeks (CDFG 1998). Other streams that may support weak or non-persistent populations include Battle, Antelope, Cottonwood, and Big Chico Creeks (CDFG 1998). Spring chinook salmon may also be present in the Feather River, another tributary to the Sacramento River. The extent of natural spawning by spring chinook in the mainstem Sacramento River is unknown. Juvenile emigration data collected at the RBDD do not show a discrete emigration of spring chinook from the upper Sacramento River; rather, most juveniles within the spring chinook size-class appear to fit better into the leading-tail of fall chinook distribution (USFWS RBFWO, unpublished data). Hybridization with fall chinook salmon is a primary concern for naturally-spawning spring chinook salmon in the mainstem Sacramento River and elsewhere, because of similar spawn timing and lack of spatial separation in limited geographic distribution.

Steelhead Trout

Run size estimates are not available for the Central Valley steelhead trout ESU prior to the construction of Shasta Dam. Early salvage investigations associated with the construction of Shasta Dam documented steelhead trout runs to the upper Sacramento River to be of "negligible" size (Hanson et al. 1940), and it is likely that steelhead trout populations in the upper Sacramento River had already been depleted considerably at that time. Following construction of Shasta Dam, steelhead trout abundance in the upper Sacramento River was believed to increase appreciably (Azevedo and Parkhurst 1958, Moffett 1949). Between 1953 and 1959, steelhead trout run-size estimates for the Sacramento River system (above Feather River) ranged from over 14,000 to over 28,000 (Hallock et al. 1961). Hallock et al. (1961) estimated a total run size of 40,000 in the Sacramento River system in the early 1960's. From 1966 through 1993 estimates of steelhead trout abundance in the upper Sacramento River were conducted by counting passage through the fish ladders at RBDD. Average escapement past RBDD for the years 1966 - 1977 (15,000) is more than eight times higher than the average return for the years 1989 - 1993 (1,855), a decline averaging 9% per year (Table 2-2).

A reliable estimate of present day steelhead trout abundance in the upper Sacramento River is not available. Standardized estimates of passage past RBDD ended in 1993 when fish ladder counts were discontinued in mid-September, thereby missing all but the earliest portion of the run. McEwan and Jackson (1996) estimated the current steelhead trout run size for the Sacramento River system at less than 10,000 adults. However, this should be considered a rough estimate because data are limited. Critical and viable population thresholds have not been determined for Central Valley steelhead trout.

Table 2-2. Fall, late-fall, winter, and spring chinook salmon and steelhead trout spawner population estimates in the Sacramento River, Battle Creek, and Coleman National Fish Hatchery, 1952-1999. Estimates from the Sacramento River include estimated harvests.

	Fall Chinook[a]			**Late-fall Chinook**[a]		**Winter Chinook**[a]	**Spring Chinook**[a]	**Steelhead Trout**[b]		
Year	**Sacramento River above Red Bluff**[c]	**Battle Creek below Coleman NFH**[d]	**Coleman NFH**	**Sacramento River Mainstem**	**Coleman NFH**	**Sacramento River Mainstem**	**Sacramento River system-wide**	**Sacramento River above Red Bluff**	**Coleman NFH**	**Year**
1952		4,000	11,000							1952
1953		4,000	12,000							1953
1954		4,000	8,000							1954
1955		16,000	10,000							1955
1956	87,357	13,650	7,458							1956
1957	54,989	2,285	3,045							1957
1958	107,153	14,600	146,432							1958
1959	256,700	19,400	108,332							1959
1960	218,940	14,200	9,605				11,068			1960
1961	140,181	11,700	8,158				4,327			1961
1962	127,837	8,200	4,857				3,642			1962
1963	138,881	12,400	5,114				10,817			1963
1964	142,584	12,000	3,875				8,021			1964
1965	101,876	6,000	3,194				1,788			1965
1966	111,881	2,400	900				427			1966
1967	82,490	2,160	3,050	37,208			476	13,488	1,532	1967
1968	98,429	2,950	3,526	34,733			663	15,771	3,229	1968
1969	115,652	3,200	2,626	38,752			21,378	9,342	4,939	1969
1970	65,142	3,320	3,512	25,310		45,673	7,672	8,423	4,406	1970
1971	53,888	3,285	2,004	16,741		53,089	9,281	7,432	3,742	1971
1972	33,958	2,030	2,882	31,559		35,929	8,876	4,272	1,486	1972
1973	41,129	4,300	3,835	21,781		22,651	11,430	5,772	2,645	1973
1974	47,019	2,294	1,607	6,083		18,536	9,248	4,967	1,834	1974
1975	53,129	2,426	2,431	19,261		23,079	23,575	4,271	1,099	1975

	Fall Chinook[a]			Late-fall Chinook[a]		Winter Chinook[a]	Spring Chinook[a]	Steelhead Trout[b]		
Year	Sacramento River above Red Bluff[c]	Battle Creek below Coleman NFH[d]	Coleman NFH	Sacramento River Mainstem	Coleman NFH	Sacramento River Mainstem	Sacramento River system-wide	Sacramento River above Red Bluff	Coleman NFH	Year
1976	45,753	3,147	2,297	15,908		33,529	25,840	6,328	2,162	1976
1977	16,176	5,604	5,244	9,210	914	16,470	13,738	3,636	2,069	1977
1978	32,235	1,770	1,882	12,479		24,735	8,126	1,697	697	1978
1979	47,758	4,430	8,729	10,284		2,339	3,116	2,469	865	1979
1980	21,961	4,940	9,503	9,093	147	1,142	12,464	6,811	4,264	1980
1981	29,212	6,933	10,272	6,571	295	19,795	22,105	2,032	1,118	1981
1982	17,966	7,270	19,525	3,981	43	1,233	27,890	1,239	1,275	1982
1983	26,226	5,277	8,756	15,984	105	1,872	7,958	2,369	938	1983
1984	36,965	8,312	21,581	9,638		2,662	9,599	1,406	529	1984
1985	52,120	23,488	16,320	9,999	181	5,048	15,221	2,008	2,084	1985
1986	67,940	18,771	12,481	7,811	197	2,394	25,524	1,032	2,229	1986
1987	75,958	7,993	16,256	15,393	349	2,045	14,128	1,563	1,176	1987
1988	64,170	53,896	13,579	11,917	53	2,803	18,895	783	915	1988
1989	48,526	19,062	11,986	11,351	65	539	12,171	0	492	1989
1990	32,013	6,453	14,635	8,276	92	472	7,557	702	1,319	1990
1991	20,235	6,558	10,683	8,237	161	190	5,921	0	991	1991
1992	23,206	5,433	7,275	10,171	344	1,246	3,045	2,996	870	1992
1993	33,824	11,029	7,587	739	528	340	6,070	553	805	1993
1994	19,699	24,274	18,991	291	598	189	6,065			1994
1995	28,030	56,515	26,677	166	323	1,230	15,131			1995
1996	30,194	52,204	21,178	48	1,337	940	8,989			1996
1997	95,505	50,743	50,670		4,578	841	5,312			1997
1998	4,824	53,957	44,351	9,717	3,069	2,509	31,594			1998
1999	48,418	92,949	26,970	8,683	7,075	3,208	10,134			1999

[a] Source: GrandTab; California Department of Fish and Game, Inland Fisheries Division, Sacramento.

[b] Source: McEwan, D. and T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, Inland Fisheries Division, Sacramento.

[c] Sacramento River mainstem above Red Bluff includes adults captured and transferred to Coleman National Fish Hatchery, 1952-1986.

[d] Battle Creek below Coleman NFH includes estimated number of naturally spawning fall chinook salmon in Battle Creek above Coleman NFH during the following years: 1958 (100); 1959 (100); 1985 (10,696); 1986 (7,263); 1987 (2,125); 1988 (1,973); and, 1989 (233).

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2.9 Status of unlisted salmonid populations affected by the program

Fall Chinook Salmon

Total abundance of the Central Valley fall chinook ESU is relatively high, perhaps near historical levels (Table 2-2). However, the abundance of populations in the San Joaquin Basin are extremely depressed compared to historic levels (Yoshiyama et al. 1998), and hatchery production comprises a substantial portion of total escapement. Returns to hatcheries account for 20% of the spawning escapement to the Central Valley, and hatchery strays spawning naturally may account for an additional 30% of the spawning escapement. Fall chinook populations that are least influenced by hatchery strays are experiencing generally negative trends in abundance.

Late-fall Chinook Salmon

Abundance estimates of late-fall chinook salmon are depressed from historic levels, but appear to be relatively stable during recent years (Table 2-2). In the late-1960's about 35,000 late-fall chinook salmon annually migrated past the RBDD. Passage estimates from 1987-1992 averaged about 11,000 annually. Since 1992, estimates of abundance of late-fall chinook salmon migrating past RBDD have not been reliable because of changes to the operation of the dam. However, carcass mark-and-recapture surveys for late-fall chinook have recently been initiated by CDFG. During the first two years of the late-fall chinook survey (1998 and 1999) approximately 9,000 late-fall chinook salmon were estimated to spawn in the upper Sacramento River (Snider et al. 1998b, Snider et al. 1999b).

2.10 Status of salmonid populations in Battle Creek

The unique hydrology and geology of the natural Battle Creek watershed ensures a reliable supply of cool water required for adult holding and spawning and year-round rearing of juveniles. Fall chinook have always comprised the largest population in Battle Creek; however, late-fall, winter, and spring chinook salmon and steelhead trout are also native to the Battle Creek watershed. Early accounts by fisheries investigators report that Battle Creek was perhaps the most important tributary for salmon production in the Sacramento River (Rutter 1903).

The unique hydrological characteristics that made Battle Creek such a productive stream for salmonid populations also led to the early development of Battle Creek for hydroelectric power generation and hatchery propagation. Both activities began prior to the 20th Century. Clark (1928) reported that spring chinook salmon were nearly extirpated in Battle Creek by 1928 as a result of water diversions and dams related to power generation. Hatchery propagation has occurred in Battle Creek since 1895. The peak of hatchery propagation in Battle Creek occurred in 1904 when 50 million eggs were collected from an estimated 10,000 female fall chinook salmon at the Battle Creek Egg Taking Station (Clark 1928). For over 100 years, naturally producing salmonid populations in Battle Creek have been affected by hydropower and hatchery activities.

The present status of naturally producing salmonid populations in Battle Creek are as follows: remnant populations of winter and spring chinook salmon exist in Battle Creek; integrated hatchery- and natural populations of fall chinook salmon and steelhead trout are abundant; and the status of naturally producing late-fall chinook salmon in Battle Creek is largely unknown.

Fall Chinook Salmon

Trends of abundance for naturally-spawning fall chinook salmon are very different for Battle Creek and the upper Sacramento River (Figure 2-1). From 1956 to 1976 the majority (80 - 90%) of fall chinook salmon migrating above RBDD spawned naturally in the mainstem Sacramento River. The remaining 10 to 20% of the fall chinook salmon migrating past RBDD returned to Battle Creek and were incorporated as broodstock at Coleman NFH or spawned naturally in Battle Creek. Since 1977 the portion of fall chinook salmon returning to Battle Creek relative to the mainstem Sacramento River has increased. This is attributed to substantially increased escapement to Battle Creek and decreased numbers of natural-origin fall chinook returning to the mainstem Sacramento River. From 1995 through 1999, the abundance of naturally-spawning fall chinook salmon in the mainstem Sacramento River averaged 46,444, whereas, an average of 95,831 fall chinook annually entered Battle Creek. During 1998, an estimated 84% of fall chinook salmon migrating above Red Bluff entered Battle Creek.

Adult fall chinook salmon spawning naturally in Battle Creek and collected as broodstock at Coleman NFH are of mixed-origin, resulting from both hatchery- and natural-production. Artificial propagation has been a major influence on fall chinook salmon in Battle Creek since the creation of the Battle Creek Egg Taking Station in the late-1890's. Broodstock for the Battle Creek Egg Taking Station were primarily natural-origin fall chinook salmon. Coleman NFH was created in 1942. Both hatchery- and natural-origin fall chinook salmon have always been used as broodstock at the Coleman NFH. In addition to integrating hatchery and natural populations at the hatchery, considerable integration also occurs through natural spawning in Battle Creek. From 1980 through 1999, an average of 24,700 fall chinook salmon spawned naturally in Battle Creek. Long-term, continuous, and extensive integration between hatchery and natural fall chinook populations has likely resulted in a genetically homogeneous population of mixed (i.e., hatchery and natural) ancestry.

Most fall chinook adults entering Battle Creek originate from artificial production at Coleman NFH or natural production occurring primarily below the Coleman barrier weir. Adult fall chinook salmon return to Battle Creek, drawn to their natal watershed by natural homing instincts. It has also been postulated that many naturally-produced adults entering Battle Creek may have been destined to spawn in the mainstem Sacramento River, but were "decoyed" into Battle Creek, attracted by pheromones exuded from large congregations of hatchery-origin adults. To address this hypothesis, we examined straying (and possible decoying) of chinook salmon into Battle Creek. Since we were unable to distinguish between natural fall chinook salmon spawned in the mainstem and those spawned in Battle Creek, we analyzed numbers of hatchery-origin fall chinook propagated on the Feather, Merced, and Mokelumne rivers returning to Battle and Clear creeks as surrogates (see Appendix 2A for a complete discussion of our analysis and results). In the five years examined (1995 through 1999), we found no evidence that these fish strayed into Battle Creek at higher rates (i.e., decoyed) than those for Clear Creek. In fact, expanded recoveries were higher for Clear Creek than Battle Creek in four of the five years examined.

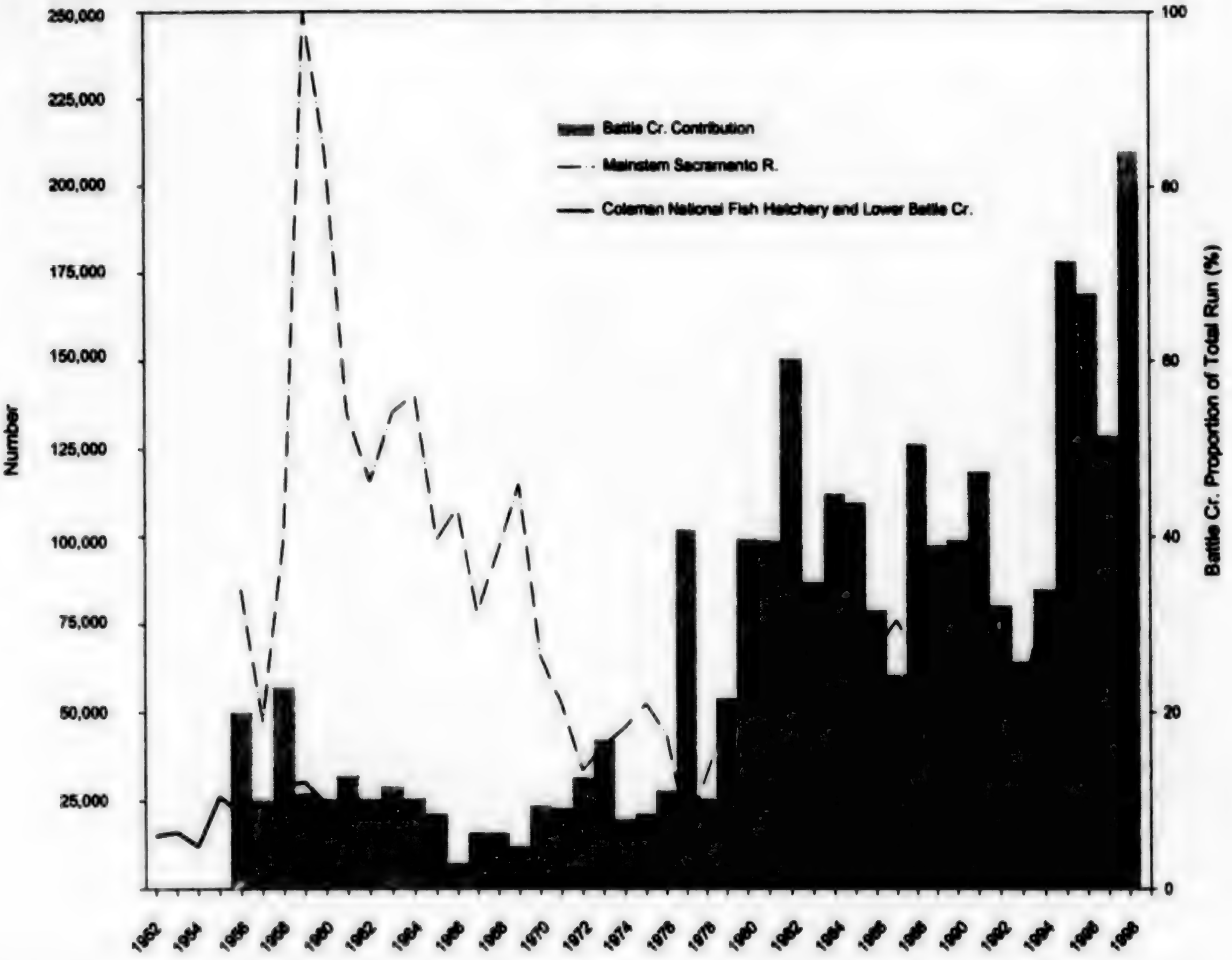

Figure 2-1. Estimated numbers of adult fall chinook salmon returning to Coleman National Fish Hatchery and lower Battle Creek, and estimates of fall chinook salmon returning to the mainstem Sacramento River for 1952-1998. Also shown is the proportion of the total run of fall chinook salmon returning to Battle Creek.

The integrated population of hatchery- and natural-origin fall chinook salmon provides a substantial level of natural production in Battle Creek. The Service has monitored the success of natural fall chinook production in Battle Creek since late-1998 using rotary screw traps located 2.8 and 5.9 miles upstream from the confluence with the Sacramento River. The upstream trap is located a short distance above the Coleman barrier weir and the downstream trap is located about three miles below the weir. Estimates of fall chinook emigration in Battle Creek generated through the juvenile monitoring program are 14 to 16 million for brood year 1998 (CH2M Hill 2001; USFWS RBFWO, unpublished data) and over 26 million for brood year 1999 (USFWS RBFWO, unpublished data). However, it is not currently known if this high level of juvenile production will result in similar levels of adult returns. Some studies on spring chinook salmon in Oregon suggest that in the natural environment, fry to smolt survival for progeny of hatchery-origin salmon can be 5% to 25% lower than the survival for progeny of naturally-produced adults (Reg Reisenbichler, USGS, Biological Resources, Seattle, WA, personal communication, Feb 8, 2001).

Spawning habitat is believed to be a primary limiting factor for natural production of fall chinook salmon in Battle Creek (Ward and Kier 1999). Based on estimates of spawning habitat availability, the AFRP escapement goal for lower Battle Creek is 5,000 adults. However, data generated through the juvenile monitoring program suggest spawner capacity may be greatly underestimated. The abundance of fall chinook spawners below the Coleman barrier weir during 1998 (53,957) and 1999 (92,049) greatly exceeded the estimated capacity of lower Battle Creek spawning and rearing habitats (GrandTab, CDFG, Red Bluff, CA). With such a high abundance of spawners in a relatively small area of suitable spawning habitat, considerable concern existed that spatial competition for spawning areas and redd superimposition would decrease juvenile production. Field observations during the spawning season corroborated the belief that redd superimposition was, in fact, prevalent in lower Battle Creek during those years. However, juvenile emigration data for 1998 and 1999 greatly exceed the estimated production capacity for lower Battle Creek[2]. These data show substantial natural production by fall chinook salmon in Battle Creek coinciding with years of substantial over-escapement to Coleman NFH. Juvenile fall chinook salmon disperse soon after emergence (Vogel and Marine 1991) and, therefore, did not appear to exceed the rearing capacity of Battle Creek. As additional habitat becomes available through Battle Creek restoration activities, natural production is expected to increase.

Late-fall Chinook Salmon

Information is scarce regarding the abundance of naturally spawning late-fall chinook salmon in Battle Creek. Generally, late-fall chinook are considered to spawn in the mainstem Sacramento River. However, some natural-origin (unmarked) and phenotypic late-fall chinook do migrate into Battle Creek and are collected at Coleman NFH. Based upon past data, fewer than thirty unmarked late-fall chinook are expected to be collected at Coleman NFH (n = 18 for 1998, approx. 6 for 1999, and 4 for 2000). Some of the unmarked late-fall chinook may actually be hatchery-origin fish that regenerated adipose fins or were inadvertently missed during the marking process. The number of late-fall chinook salmon spawning naturally below the Coleman NFH barrier weir is unknown, but is presumed to be small.

Winter Chinook Salmon

Winter chinook salmon are indigenous to Battle Creek. Historic run-size estimates are unavailable, however, because unfavorable environmental conditions exist during the time of year when winter chinook salmon migrate. Population estimates of winter chinook salmon have been conducted in Battle Creek since 1995 as part of the Service's monitoring program for hatchery-origin winter chinook salmon. These monitoring efforts documented the unintended return of hatchery-origin winter chinook salmon to Battle Creek. From 1996 through 2000, hatchery-origin winter chinook salmon returning to Battle Creek have been relocated to the mainstem Sacramento River, the target of the supplementation program. During 2000, two hatchery-origin (adipose fin-clipped) winter chinook salmon homed to Battle Creek, the previous site of the winter chinook supplementation program. The winter chinook propagation program was moved to Livingston Stone NFH in 1997; therefore, no hatchery-origin winter chinook salmon are expected to return to Battle Creek in future years.

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[2] A spawning population of 5,000 fall chinook salmon adults in Battle Creek is expected to result in 3.1 million fry based on a fecundity estimate of 5,000 eggs per female (USFWS 1993, Ward and Kier 1999) and a 25% egg-to-fry survival rate (USFWS 1993).

During recent years, a small number of natural-origin winter chinook salmon adults have returned to Battle Creek. Monitoring conducted at the Coleman barrier weir during 2000 showed that 3 natural-origin (unmarked) winter chinook salmon migrated past the Coleman barrier weir.

Spring Chinook Salmon

Historic run-size estimates for spring chinook salmon in Battle Creek are incomplete. Available estimates begin in 1943 with the initiation of the spring chinook salmon propagation program at Coleman NFH. Data presented in Fry (1961) are rounded estimates based on Service counts. These data suggest less than 500 spring chinook were counted annually between 1943 through 1945, as well as in 1948 and 1949. In all other years (1946, 1947, and 1950-1956), the estimate ranged between 1,000 and 2,000 (Fry 1961). No population estimates were performed from 1956 to 1994. Population estimates for spring chinook salmon in Battle Creek since 1995, when available, have been less than 100 (66 in 1996, 34 in 1997, and 40 in 2000; USFWS 1996b; USFWS 1998; USFWS RBFWO, unpublished data).

Adult spring chinook salmon are believed to migrate into Battle Creek primarily during April, May, and June, similar to migration patters in Mill and Deer Creeks. However, historic migration timing for spring chinook salmon extends into November and overlaps considerably with fall chinook salmon. Monitoring of adult passage conducted at the upstream ladder of the Coleman barrier weir in 2000 showed infrequent passage of chinook salmon through mid-July (USFWS, RBFWO, unpublished data). Thereafter, chinook salmon migration past the Coleman barrier weir ceased from mid-July to mid-August. Water temperatures in lower Battle Creek typically exceed the temperature suitability range of chinook salmon during these months. Adult chinook salmon were again observed at the Coleman barrier weir after mid-August, 2000. However, considering the larger number of fish encountered at that time, it appears that those fish were likely early-arriving fall chinook salmon. Spring chinook salmon entering Battle Creek at that time of year would not be distinguished from early-arriving fall chinook salmon.

Steelhead Trout

Historically, steelhead trout are believed to inhabit nearly all tributaries of the Sacramento River, including Battle Creek. However, historic steelhead trout run-size estimates do not exist for Battle Creek. Circumstantial evidence suggests that the steelhead trout run in Battle Creek was relatively small prior to the propagation of that species at the Coleman NFH. When the Coleman NFH steelhead program was initiated in 1947, founding broodstock were transported to the hatchery from the Sacramento River at the Keswick fish trap. An on-site captive rearing program was used to supply broodstock for three years until returns of hatchery-origin steelhead trout were sufficient to meet spawning goals.

Nearly all steelhead trout migrate during the period of broodstock collection at Coleman NFH, and, with the exception of escapement above the Coleman barrier weir, nearly all steelhead trout enter the

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adult collection ponds at Coleman NFH. Typically, about 60% of steelhead trout collected at Coleman NFH enter the hatchery ponds prior to January 1 (USFWS, Coleman NFH unpublished data) and nearly all have arrived at the hatchery by late-February. A small number of steelhead trout migrate into Battle Creek from March through April and are allowed to ascend through the upstream ladder of the Coleman barrier weir.

The existing population of steelhead trout in Battle Creek is comprised of a mixture of hatchery- and natural-origin adults. Since the early-1950's, artificial propagation has had a major influence on steelhead trout in Battle Creek. Because hatchery and natural-origin steelhead trout were not differentiable based on appearance, both have been used as broodstock at Coleman NFH. In addition to integrating hatchery and natural populations as hatchery broodstock, considerable integration also occurs through natural spawning in Battle Creek. Spawning records from 1953 through 1995 at Coleman NFH indicate frequent releases of adults above the Coleman barrier weir (USFWS, Coleman NFH unpublished data). In more recent years, (i.e., since 1996), large numbers of hatchery and (presumably) natural adult steelhead trout have been passed above the Coleman NFH barrier weir to spawn naturally in upper Battle Creek[3] (Figure 2-2). Between 1999 and 2001, over 1,000 steelhead trout per year were passed upstream of the Coleman barrier weir to spawn naturally. Long-term, continuous, and extensive integration between hatchery and natural steelhead trout populations has likely resulted in a genetically homogeneous population.

Until recently, reliable information regarding the size of the naturally spawning steelhead trout population in Battle Creek was unavailable. Prior to brood year 1997, nearly all hatchery-origin steelhead trout from Coleman NFH were unmarked, so returning hatchery-origin adults could not be differentiated from natural-origin steelhead trout. A complete (i.e., 100%) mass mark was instituted at Coleman NFH beginning in 1998. As a result of the mass marking program, essentially all hatchery-origin steelhead trout returning to Battle Creek after 2000 will be identifiable by a clipped adipose fin. During hatchery broodstock collection activities extending from October 2000 through February 2001, 131 unmarked steelhead trout returned to Coleman NFH. These likely represent a naturally produced run in Battle Creek. These fish are believed to be mostly 3-year olds, produced primarily by 418 steelhead trout passed above the Coleman barrier weir during broodstock collections of 1997-1998. During the next few years it is expected that increased numbers of natural-origin steelhead trout will return to Battle Creek as a result of the large numbers of adults passed above the Coleman barrier weir since 1999 (>1,000 annually). All steelhead trout collected at Coleman NFH will be counted and identified to origin (i.e., hatchery or natural) to monitor and evaluate recovery of the natural population in Battle Creek.

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[3] This action was originally executed at the request of the California Department of Fish and Game in 1995 at the Coleman National Fish Hatchery Annual Production/Coordination Meeting. The request followed the development of an interim flow agreement with PG&E to increase instream flows in the Battle Creek watershed.

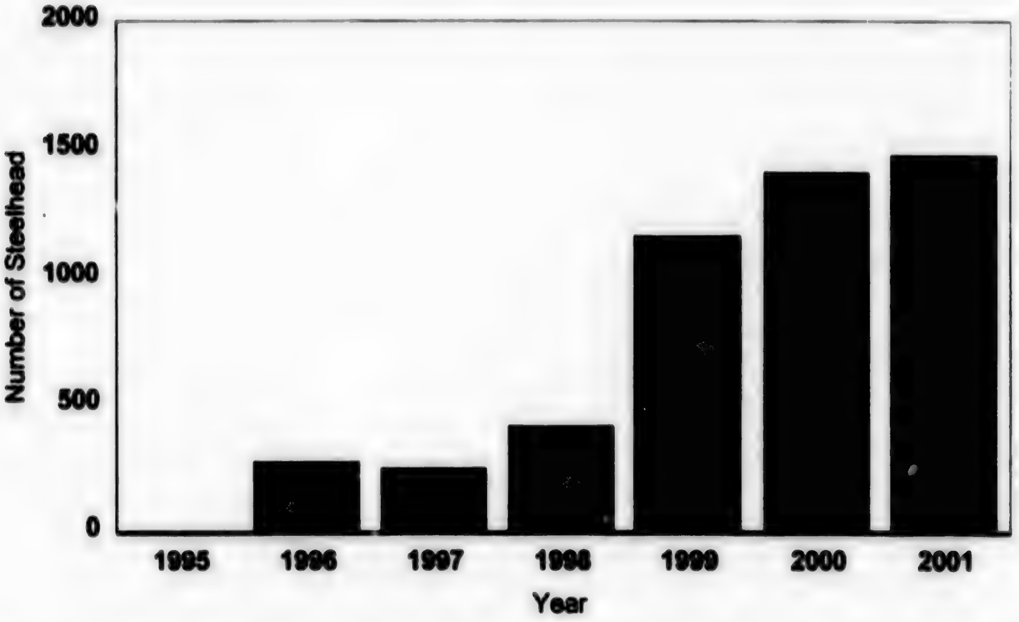

Figure 2-2. Numbers of returning steelhead adults intentionally passed upstream of the Coleman National Fish Hatchery barrier weir from1995 through 2001.

2.11 Description of hatchery activities that may lead to the take of listed salmonid populations, the risk potential for their occurrence, and the likely effects of the take.

Risk Assessment Framework

From an ESA perspective, the primary goal of an impact analysis is to assess the likelihood for an action or group of actions to adversely affect a listed *population*, thus jeopardizing the future existence of the population. This assessment of jeopardy or "risk" is based on the concept of population viability. Population viability is defined as the probability that a population can continue to perpetuate itself, and is a function of the population's current abundance and fitness as well as its environment.

We have assessed activities associated with artificial production programs at Coleman and Livingston Stone NFH's in regards to their potential impacts to the viability of listed salmonid populations. To accomplish this, we first determined the likelihood that an individual fish or group of fish would incur negative impacts when exposed directly to the activity, or as a consequence of the activity. Secondly, when our assessments indicated that a hatchery activity was likely to negatively impact individual listed fish, we considered potential impacts at the population level by evaluating factors such as: the severity of impact (e.g., short-term migration delay, injury, or death); the number of individuals to be impacted; and, population status. For example, although an impact may be high on an individual (e.g., high potential for mortality if exposed directly to a hatchery activity), if limited numbers of individuals may be impacted, the overall impact at the population level could be "moderate" or "low".

Population-level impacts of hatchery operations were characterized as: No impact, Low Impact, Moderate Impact, and High Impact. Definitions of these impacts were adopted from Bonneville Power Administration (1997).

No Impact: Activity will not affect fish abundance

Low Impact: Activity likely to result in a small change of abundance, but would remain within expected year-to-year variability, and would not ultimately effect population viability.

Moderate Impact: Action is likely to produce a moderate change in abundance similar in magnitude to changes in abundance witnessed during atypical conditions (i.e., drought). Should conditions or impacts persist, population viability may be affected.

High Impact: Likely to cause large immediate changes in abundance such as a catastrophic natural event.

Hatchery Activities Potentially Impacting Natural Salmonid Populations and Summary of Impact Assessment

Activities associated with fish propagation at Coleman and Livingston Stone NFH have the potential to result in direct and incidental take of ESA-listed species of anadromous salmonids, or destroy or alter critical habitats. Hatchery operations that may negatively impact listed and candidate stocks of anadromous salmonids or their critical habitats can be classified into four main categories: 1) facility maintenance and on-site construction; 2) on-site fish production operations; 3) interactions following fish releases; and, 4) impacts associated with contributing or returning adults. These four main categories have been separated into specific program activities to identify certain aspects of hatchery operations that may result in take of listed salmonids:

1) Facility maintenance and on-site construction
    - Grounds Maintenance
    - On-site Construction

2) On-site fish production operations
    - Hatchery Water Diversions
    - Water Discharge
    - Broodstock Collection (fish ladders, weirs, and traps)
    - Broodstock Maintenance and Selection
    - Broodstock Mating
    - Juvenile Incubation and Rearing

3) Effects of fish releases
   - Competition/Displacement
   - Predation
   - Altered Migration of Juveniles
   - Disease Transmission
   - Increased Straying (particularly with off-site releases)

4) Impacts associated with contributing or returning adults
   - Harvest
   - (Over) Escapement
   - Decoying

Each of the program activities associated with artificial propagation at Coleman and Livingston Stone NFH's were evaluated in regards to the likelihood to adversely affect ESA-listed salmonids through direct or indirect take or alteration/destruction of critical habitat. Whenever data were available, quantitative evaluations of impacts, or take, have been generated. Quantitative estimates of unintentional take of ESA-listed salmonids were calculated for broodstock congregation and collection activities and water diversions from Battle Creek. Take resulting from water diversions from Battle Creek may occur as either entrainment or impingement of juvenile salmonids, potentially causing mortality. Take resulting from broodstock congregation and collection in Battle Creek could result in migration delay, blockage, or unintentional lethal take. Broodstock collection at the fish traps at Keswick Dam and RBDD could result in various combinations of capture, handle, transport, tissue sample, or unintentional mortality of ESA-listed species. Projected levels of unintentional take resulting from artificial propagation programs at Coleman and Livingston Stone NFH's are summarized in Table 2-3. Derivation of these take estimates and estimates of take for non-listed salmonids are explained in Section 4 (water source) and Section 7 (broodstock congregation and collection).

Potential impacts associated with other hatchery activities, however, would not permit a quantitative assessment of take because data were not available or potential impacts are largely speculative. This inability to quantify impacts is due to the complex biology of salmon and steelhead trout and the multitude of other actions that simultaneously affect natural salmonid populations. When available data did not permit calculation of a quantitative estimate of take, impacts associated with hatchery facilities and operations were assessed qualitatively. For example, data are not available to quantitatively assess impacts to listed salmonid populations related to inter-specific and intra-specific competition resulting from hatchery releases of juveniles. In this situation, we have assessed impacts resulting from juvenile releases based substantially on a qualitative assessment of risks, drawing information from literature and details related specifically to artificial propagation programs at Coleman and Livingston Stone NFH's. A summary of the qualitative estimates of take resulting from artificial propagation programs at Coleman and Livingston Stone NFH's is presented in Table 2-4. Specifics are presented in the appropriate sections of this document.

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Based on our qualitative and quantitative assessments of impacts resulting from artificial propagation programs at Coleman and Livingston Stone NFH's, we have assessed the likelihood that hatchery facilities and operations will adversely affect anadromous salmonid populations and jeopardize the future existence of those populations. From our analyses, we conclude that artificial propagation programs at Coleman and Livingston Stone NFH's are not likely to pose serious threats to the viability of natural salmonid populations.

Table 2-3. Projected levels and types of incidental take of listed salmonids resulting from artificial propagation programs at Coleman and Livingston Stone National Fish Hatcheries. Take of adults in indicated by "A" and juveniles by "J". Where a fish may be affected by more than one activity, it is included in the category that would have the greatest impact. Winter chinook collected from the Sacramento River are intentionally taken as broodstock, so unintentional take from this location is not applicable (n.a.).

	Affected Stock		
	Winter Chinook	Spring Chinook	Steelhead Trout
Battle Creek			
Entrainment or impingement (J)	7,013	933	7,641
Delay at Coleman barrier weir (A)[a]	83	100	100
Capture, handle, hold, release (A)	17	0[b]	1,450
Unintentional lethal take (A)	1	1	15
Sacramento River			
Capture, handle, transport, and release (A)	n.a.	0	1,000
Capture, handle, transport, tissue sample, and release (A)	n.a.	155	0
Unintentional lethal take (A)	n.a.	7	20

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[a] While the upstream fish ladder is open, it is possible that some of these fish may be unable to find the ladder and pass upstream. These fish would be blocked at the Coleman barrier weir.

[b] As part of an interagency agreement between the Service, NMFS and CDFG, the Coleman barrier weir is closed on September 1 to prevent fall chinook salmon from passing upstream and potentially spawning with spring chinook. This decision is not related to hatchery operations. If spring chinook salmon arrived late (after September 1) and entered Battle Creek, they would be blocked from passing upstream by the barrier weir.

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Table 2-4. Qualitative summary of population-level impacts associated with fish production activities conducted at Coleman and Livingston Stone National Fish Hatcheries that may result in direct or indirect take of ESA-listed and non-listed species, or destruction or alteration of critical habitat. Impact assessment is based on discussions, data, and analyses presented in this document and represent the U.S. Fish and Wildlife Service's evaluation of available information. Complete discussions of these activities and impacts can be found in the specified sections of this document.

General Category	Activity	Species Impacted	Assessment of Population-level Impact	Sections in Document
Facility Maintenance and On-site Construction	Grounds Maintenance and Site Disturbances at Coleman NFH	Fall Chinook	none to low	5.1 for description
		Late-fall Chinook	none to low	
		Winter Chinook	none to low	
		Spring Chinook	none to low	
		Steelhead Trout	none to low	
	Grounds Maintenance and Site Disturbances at Livingston Stone NFH	Fall Chinook	none to low	5.2 for description
		Late-fall Chinook	none to low	
		Winter Chinook	none to low	
		Spring Chinook	none to low	
		Steelhead Trout	none to low	
On-site fish production operations	Water Intake and Use at Coleman NFH	Fall Chinook	See Table 4-3 for quantitative assessment of take for all stocks.	4.1 for description of Intakes 4.3, 4.4, and Appendix 4A for derivation and estimates of take 4.5 for a discussion of effects on critical habitat.
		Late-fall Chinook		
		Winter Chinook		
		Spring Chinook		
		Steelhead Trout		
	Water Intake and Use at Livingston Stone NFH	Fall Chinook	none	4.2 for description of water source 4.3 for impact assessment
		Late-fall Chinook	none	
		Winter Chinook	none	
		Spring Chinook	none	
		Steelhead Trout	none	
	Water Discharge at Coleman NFH	Fall Chinook	none to low	4.1 for description of water treatment facility and water discharge, and for impact assessment
		Late-fall Chinook	none to low	
		Winter Chinook	none to low	
		Spring Chinook	none to low	
		Steelhead Trout	none to low	

Table 2-4 (cont.). Qualitative summary of population-level impacts associated with fish production activities conducted at Coleman and Livingston Stone National Fish Hatcheries that may result in direct or indirect take of ESA-listed and non-listed species, or destruction or alteration of critical habitat. Impact assessment is based on discussions, data, and analyses presented in this document and represent the U.S. Fish and Wildlife Service's evaluation of available information. Complete discussions of these activities and impacts can be found in the specified sections of this document.

General Category	Activity	Species Impacted	Assessment of Population-level Impact	Sections in Document
On-site fish production operations (cont.)	Water Discharge at Livingston Stone NFH	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	none to low none to low none to low none to low none to low	4.2 for description of water discharge and impact assessment
	Broodstock Congregation and Collection at Battle Creek	Winter Chinook Spring Chinook Steelhead Trout	See Table 7-9 for quantitative assessment.	7.2 and 7.3 for description of congregation and collection of broodstock 7.10 for discussion of derivation and Table 7-9 for estimate of take
	Broodstock Congregation and Collection at Sacramento River	Winter Chinook Spring Chinook Steelhead Trout	See Table 7-10 for quantitative assessment.	7.2 and 7.3 for description of congregation and collection of broodstock 7.10 for discussion of derivation and Table 7-10 for estimate of take of ESA-listed stocks
	Broodstock Selection, Mating and Genetic Implications	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	low low low low low	6.1 and 6.5 for broodstock origin and incorporation of natural adults 6.6 for discussion of genetic or ecological differences Appendix 6D for discussion of genetic risks 7.4 for identification of broodstock 6.8 and 7.9 for discussion of risks and risk aversion methods.

Table 2-4 (cont.). Qualitative summary of population-level impacts associated with fish production activities conducted at Coleman and Livingston Stone National Fish Hatcheries that may result in direct or indirect take of ESA-listed and non-listed species, or destruction or alteration of critical habitat. Impact assessment is based on discussions, data, and analyses presented in this document and represent the U.S. Fish and Wildlife Service's evaluation of available information. Complete discussions of these activities and impacts can be found in the specified sections of this document.

General Category	Activity	Species Impacted	Assessment of Population-level Impact	Sections in Document
On-site fish production operations (cont.)	Incubation and Rearing	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	none none none none none	9.1 for description of incubation and 9.2 for descripoon of rearing No impacts are expected from on-site incubation and rearing. Impacts associated with water use, water discharge, and juvenile releases are covered in Sections 4 and 10 respectively.
Juvenile Releases	Fall Chinook	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	none to low none to low none to low none to low none to low	10.8 and 10.12 for a discussion of effects on natural populations Table 10-11 for a summary of qualitative assessment. Appendix 10C for analysis of straying
	Late-fall Chinook	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	low to moderate low low low low	10.9 and 10.12 for a discussion of effects on natural populations Table 10-13 for a summary of qualitative assessment. Appendix 10C for analysis of straying
	Winter Chinook	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	none none none none none	10.10 and 10.12 for a discussion of effects on natural populations Table 10-15 for a summary of qualitative assessment. Appendix 10C for analysis of straying

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Table 2-4 (cont.). Qualitative summary of population-level impacts associated with fish production activities conducted at Coleman and Livingston Stone National Fish Hatcheries that may result in direct or indirect take of ESA-listed and non-listed species, or destruction or alteration of critical habitat. Impact assessment is based on discussions, data, and analyses presented in this document and represent the U.S. Fish and Wildlife Service's evaluation of available information. Complete discussions of these activities and impacts can be found in the specified sections of this document.

General Category	Activity	Species Impacted	Assessment of Population-level Impact	Sections in Document
Juvenile Releases (cont.)	Steelhead Trout	Fall Chinook	none to moderate	10.11 and 10.12 for a discussion of effects on natural populations
		Late-fall Chinook	none to low	
		Winter Chinook	none to low	Table 10-16 for a summary of qualitative assessment.
		Spring Chinook	none to low	
		Steelhead Trout	none to low	
Adult Contribution	Harvest	Fall Chinook	unknown	3.5 for discussion of chinook contribution to harvest
		Late-fall Chinook	unknown	
		Winter Chinook	unknown	3.8 for discussion of relationship between harvest and escapement
		Spring Chinook	unknown	
		Steelhead Trout	unknown, likely low	Data on Steelhead Trout harvest are lacking.
	Escapement	Fall Chinook	low	3.6for discussion of escapement to Battle Creek
		Late-fall Chinook	low	3.7 and Appendix 3D for impacts of hatchery (over) escapement
		Winter Chinook	low	
		Spring Chinook	low	3.8 for discussion of relationship between harvest and escapement
		Steelhead Trout	low	
	Straying	Fall Chinook	low	Section 10.12 and Appendix 10C for analysis of stray rates and associated impacts
		Late-fall Chinook	low to medium	
		Winter Chinook	low	
		Spring Chinook	low	
		Steelhead Trout	low	

Table 2-4 (cont.). Qualitative summary of population-level impacts associated with fish production activities conducted at Coleman and Livingston Stone National Fish Hatcheries that may result in direct or indirect take of ESA-listed and non-listed species, or destruction or alteration of critical habitat. Impact assessment is based on discussions, data, and analyses presented in this document and represent the U.S. Fish and Wildlife Service's evaluation of available information. Complete discussions of these activities and impacts can be found in the specified sections of this document.

General Category	Activity	Species Impacted	Assessment of Population-level Impact	Sections in Document
Adult Contribution (cont.)	Decoying	Fall Chinook Late-fall Chinook Winter Chinook Spring Chinook Steelhead Trout	low none to low none to low none to low none to low	2.10 for a brief discussion in relation to hatchery-origin fall chinook Appendix 2A for analysis of decoying and associated impacts Minimal risk of decoying is expected from returns of hatchery-origin late-fall or winter chinook salmon or steelhead trout because numbers of returning adults are low (usually < 5,000).

RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

In Section 3 we describe the relationship between artificial propagation programs at Coleman and Livingston Stone NFH's and other fishery and habitat management objectives and conservation programs in the Central Valley of California. Current and proposed hatchery operations are discussed in relation to major conservation programs designed to restore and recover anadromous salmonids and their habitats in the Central Valley, including: the Central Valley Project Improvement Act (CVPIA) and associated Anadromous Fish Restoration Program (AFRP), and the CALFED Ecosystem Restoration Program (ERP). In this section we also describe the Coleman NFH Re-evaluation Process with its objectives to assess and refine hatchery facilities and operations, and the relationship between Coleman NFH and the Battle Creek Restoration process. We discuss the roles of the U.S. Bureau of Reclamation (primary funding source) and the U.S. Fish and Wildlife Service (operational responsibilities) relative to responsibilities to mitigate for habitat losses due to the Construction of Shasta Dam. Lastly, in Section 3 we describe harvest objectives for Coleman NFH, and identify contribution rates of the chinook salmon propagation programs to the ocean (commercial and sport) and the in-river sport fisheries. Furthermore, because harvest of fish from Coleman NFH and adult escapement to Battle Creek are closely linked, a discussion is presented on historical and recent adult escapement as a result of hatchery operations, and the potential impact of escapement or over-escapement of hatchery-origin adults back to the Battle Creek watershed.

3.1 Existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates

The following bullets highlight the Interagency Agreement between the Service and the U.S. Bureau of Reclamation (USBR) for the operation and funding responsibilities of Coleman NFH. A more detailed description is presented following the bulleted list.

- The Bureau of Reclamation built Coleman NFH in 1942 to partially mitigate for fishery damage resulting from habitat losses due to the construction of Shasta and Keswick Dams on the upper Sacramento River. Through a 1948 Memorandum of Agreement with the USBR, the Service assumed complete responsibility for operations and maintenance at the Coleman NFH beginning in 1950.

- A 1993 Interagency Agreement between the Service and the USBR addressed funding and operation of the Coleman NFH as a feature of the CVP (Attachment 3-1). This agreement stipulates that the Service will continue to operate, maintain and evaluate the facility "for the salvage, protection, and preservation of fish which spawned in the upper

Sacramento River Basin prior to the construction of Shasta and Keswick dams," while the USBR will (re)assume all financial responsibility for the facility and arrange for recovery costs from project beneficiaries in accordance with Federal reclamation law.

- The Central Valley Project Improvement Act (CVPIA, Title XXXIV of the Act of October 30, 1992 (Public Law No. 102-575), authorized the rehabilitation of the Coleman NFH through the execution of the 1987 Coleman NFH Station Development Plan (Service 1987).

3.2 History of the current Interagency Agreement

The Bureau of Reclamation constructed the CVP to serve a variety of purposes such as irrigation, electrical power generation, and flood control. The two project dams, however, adversely affected fishery resources in the Sacramento River system. The Keswick Dam constructed between 1940 and 1951, and the Shasta Dam constructed between 1938 and 1944 became impassable barriers to salmonids migrating upstream. Together, the two dams permanently denied access to 187 miles of anadromous fish (salmon and steelhead) habitat.

To mitigate a portion of this fishery damage, the USBR built Coleman NFH. Until 1950, the USBR transferred appropriate funds to the Service for the operation of the hatchery. Beginning with fiscal year 1950, through a 1948 memorandum of agreement, the Service assumed complete responsibility for the operations and maintenance of the hatchery, and for requesting the appropriate funds for operation and maintenance of the facility.

In 1985, after a comprehensive review of its fishery resources program, the Service developed a "Statement of Responsibilities and Role," which detailed four areas of responsibility, including to seek and provide for mitigation of important fishery resource losses caused by federal water-related development. As part of this responsibility, the Service was required to pursue recovery of costs related to hatcheries that had been constructed and operated to mitigate for federal water projects. Nine hatcheries built by the USBR and funded and operated by the Service were identified in the document by name, including the Coleman NFH. Previous changes in federal law had also stipulated that water project beneficiaries were to be held responsible by the developing agency (e.g., the USBR) for the costs of constructing, operating, and maintaining measures to prevent or compensate for fisheries damages. This requirement was in accord with the government's "user pay" policy to seek equitable ways to reduce the federal deficit.

An audit conducted between April 1989 and June 1990, found that Service funding of artificial propagation activities at Coleman NFH between the years of 1950 and 1989 was largely inappropriate, and that 73% of the expended funds should have been recovered from project beneficiaries. The audit suggested that these funds would have been available had the USBR continued to directly fund the hatchery as was the case prior to the 1948 memorandum of agreement. The audit also noted that the CVP authorization supported this finding, as did also the cost recovery language contained in pertinent legislation including the Reclamation Acts of 1902 and 1939 (amended). These acts, particularly the Act of August 4, 1939, provided specific

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authority for the Secretary of the Interior to enter into contracts to sell water and power at rates covering an appropriate share of the annual operating and fixed costs of the project facilities. The Coleman NFH is considered part of the overall CVP. The audit resulted in the development of the existing 1993 *Interagency Agreement between U.S. Fish and Wildlife Service and Bureau of Reclamation* concerning the funding and operation of the Coleman NFH as a feature of the CVP (Attachment 3-1).

The existing 1993 Interagency Agreement now supercedes all previous agreements between the Service and the USBR pertaining to the operation and funding of Coleman NFH. The agreement stipulates that the Service will continue to operate, maintain and evaluate the facility "for the salvage, protection, and preservation of fish which spawned in the upper Sacramento River Basin prior to the construction of Shasta and Keswick dams," while the USBR will reassume all financial responsibility for the facility and arrange for recovery costs from project beneficiaries in accordance with federal reclamation law.

3.3 Integration of artificial propagation programs at Coleman NFH with conservation initiatives developed to conserve and restore anadromous fish resources and their habitats

Several programs are in place to restore and recover anadromous salmonids and their habitats in the Central Valley, including: the Central Valley Project Improvement Act (CVPIA) and associated Anadromous Fish Restoration Program (AFRP), and the CALFED Ecosystem Restoration Program (ERP). These programs are designed to address the complex biological, economic, social, and technological issues necessary to restore populations of naturally reproducing anadromous salmonids and their Central Valley habitats. More watershed-specific goals for Battle Creek, including the Battle Creek Restoration Program and the Coleman NFH Re-evaluation Process, have also been developed and are in alignment with the valley-wide restoration programs.

Following is a discussion of the relationships between artificial propagation programs conducted at Coleman NFH and the CVPIA, AFRP, CALFED, the Battle Creek Restoration program, and the Coleman NFH Re-evaluation Process. With completed and pending improvements at Coleman NFH, in conjunction with adaptively-managed propagation strategies and goals, the Coleman and Livingston Stone NFH's attempt to fulfill the federal government's responsibility of mitigating for habitat losses resulting from construction of Shasta Dam while minimizing the potential for adverse effects on natural salmonid populations.

The Central Valley Project Improvement Act

Program Overview - The Central Valley Project Improvement Act (CVPIA) of October 1992 (Public Law 102-575, Title 34) is intended to remedy habitat and other problems associated with the USBR's Central Valley Project. The CVPIA amends the authority of the CVP to include fish and wildlife protection, restoration, and mitigation as equal priorities with other CVP functions such as navigation, flood control, irrigation, and municipal water supply. The CVPIA has two key features to benefit anadromous salmonids: First, Section 3406(b)(1) of the CVPIA directs the Department of the Interior to "develop...and implement a program which makes all reasonable efforts to ensure that, by the year 2002, *natural production* of anadromous fishes in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967 - 1991...." [emphasis added]. Second, Section 3406(b)(2) authorizes the use of 800,000 acre-feet of CVP water rights for fish, wildlife, and habitat restoration purposes. The Central Valley Project Restoration Fund was established to contribute to the goals of the CVPIA. The CVPIA provides the Secretary of the Interior the authority to use the fund "to carry out the habitat restoration, improvement , and acquisition (from willing sellers) provisions" necessary to fulfill the requirements of the CVPIA. For a complete description of the CVPIA refer to the following documents:

1) USFWS and USBR. 1999. Central Valley Project Improvement Act: Final Programmatic Environmental Impact Statement. Sacramento, California. October 1999.

2) USFWS and USBR. 2001. Record of Decision: Central Valley Project Improvement Act: Final Programmatic Environmental Impact Statement. Sacramento, California.

Implementation of the CVPIA at Coleman NFH - Rehabilitation of the Coleman NFH (a mitigation feature of the CVP) was authorized through the CVPIA by implementing the Station Development Plan (USFWS 1987). In the last 12 years, approximately $30 million have been expended to renovate the hatchery facilities. Completed and ongoing modifications to hatchery facilities include: 1) construction of an ozone water treatment plant and water filtration system; 2) screening of the hatchery's water intakes; and, 3) modifications to the hatchery's barrier weir and upstream fish ladder. These modifications will help to integrate artificial propagation activities at Coleman NFH with the restoration of natural salmonid populations in the Battle Creek watershed as follows:

1) The newly-constructed water treatment plant at Coleman NFH is capable of sand filtering 45,000 gpm and treating with ozone 30,000 gpm of fish production water. Water treatment capabilities of the new system will alleviate concerns of passing potentially disease-carrying fish into upper Battle Creek, where the hatchery obtains its water. Lower incidence of infection or disease on-station will also reduce the potential for transmission of disease to natural populations (either through effluent discharge or following the release of hatchery juveniles).

2) An interim juvenile fish screen has been installed for one of Coleman NFH's water intakes, and plans are underway to install new screens (where needed) to avoid impacts to naturally-produced fish in Battle Creek. The new fish screens will comply with screening criteria established by the NMFS and CDFG. This will be the first Service hatchery meeting these criteria.

3) The hatchery's barrier weir and fish ladders are being re-engineered to improve management of fish passage and monitoring. Controlled passage and monitoring of chinook salmon and steelhead trout into the upper Battle Creek watershed allows for segregation and enumeration of runs at that point, thus affording the capability to measure and maximize restoration benefits for "at-risk" priority stocks.

The Anadromous Fish Restoration Program

Program Overview - The Anadromous Fish Restoration Program (AFRP) was developed by the Secretary of the Department of the Interior to accomplish the fish population restoration goals identified in the CVPIA. Within the AFRP, watersheds, or parts of watersheds, have been prioritized for restoration actions based on a combination of biological and non-biological factors. Specific numeric population recovery goals have been determined for each watershed or watershed portion, including the Sacramento River and Battle Creek. Because the Secretary does not have direct authority to implement restoration actions in all streams, implementation of the AFRP relies heavily upon cooperation through partnerships, including state and federal agencies, watershed workgroups, conservation groups, water districts, and property owners. For a complete description of the AFRP refer to the following documents or URL.

1) USFWS. 2001. Final restoration plan for the Anadromous Fish Restoration Program. Sacramento, California.

2) USFWS. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group, Stockton, California. May 1995.

3) AFRP website http://www.delta.dfg.ca.gov/usfws/afrp/afrp.html

A total of 172 actions and 117 evaluations are identified in the AFRP that, when implemented, are intended to increase anadromous fish populations throughout the Central Valley to twice the average levels from 1967 through 1991 as specified by the CVPIA (USFWS 2001).

Implementation of the AFRP at the Coleman NFH - Several actions and evaluations identified in the AFRP pertain directly to hatchery facilities and operations that could limit natural production of anadromous fish. Specific AFRP actions and evaluations and corresponding changes that have been implemented at Coleman NFH to help to bring the hatchery into alignment with the AFRP are identified below:

Central-Valley wide Evaluation 2)	Evaluate the potential to modify hatchery procedures to benefit native stocks of salmonids

Numerous activities at Coleman NFH have been modified to benefit Central Valley anadromous fish populations. Notable changes at Coleman NFH include: discontinuing releases of fall chinook fry, and extending the time allowed for passage through the Coleman barrier weir. In addition, the Service initiated the Coleman NFH Reevaluation process. One of the main objectives of this reevaluation is to assess impacts to natural populations resulting from hatchery programs with the goal of identifying alternative strategies to reduce or eliminate these impacts (see subsection on Coleman NFH Reevaluation in this Section).

Central-Valley wide Evaluation 3) Evaluation of the impacts of hatchery juvenile release practices on natural stocks.

Hatchery release practices at Coleman NFH have been continually monitored, evaluated, and adapted to minimize negative impacts to natural salmonid populations. A summary of impacts resulting from the release of hatchery-origin juveniles is included in this document (Section 10). Additional basin-specific research on the effects of competition and displacement resulting from the release of hatchery-origin salmon is underway (see Section 12, and Attachments 12-1 and 12-2).

Central-Valley wide Evaluation 4) Evaluate and implement specific spawning protocols and genetic evaluation programs to maintain genetic diversity in natural and hatchery stocks.

The winter chinook salmon propagation at Livingston Stone NFH utilizes the latest research and technology in genetic monitoring. Other Coleman NFH propagation programs incorporate protocols to minimize genetic risks associated with artificial production programs (See Sections 6, 7, and 8, for descriptions of broodstock source(s), selection, and mating protocols. See Appendix 6D for a discussion of potential genetic impacts).

Central-Valley wide Evaluation 5) Evaluate disease transfer between hatchery and natural stocks.

Numerous field and laboratory experiments to evaluate disease transfer between hatchery and natural stocks have been conducted by the Service's California- Nevada Fish Health Center (see Section 10). Additionally, the completion of the ozone water treatment facility will reduce the potential for disease transmission to natural stocks by reducing the incidence of disease within the hatchery.

The CALFED Ecosystem Restoration Program

Program Overview - The CALFED Program is a collaboration of 15 state and federal agencies working together to develop a long-term plan to restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. Four equally-important purposes of the CALFED program are to: 1) improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta; 2) provide good water quality for beneficial uses; 3) reduce the deficit between Bay-Delta water supplies and current and projected beneficial uses; and, 4) reduce the risk to land use and associated economic activities, water supply infrastructure, and ecosystem from catastrophic breaching of Delta levees. A major element of the CALFED program is the Ecosystem Restoration Program (ERP). The ERP is designed to improve and increase aquatic and terrestrial habitats and improve ecological functions to support sustainable populations of diverse and valuable plant and animal species. Major elements of the ERP are directed at recovering endangered species, eliminating the need for additional listings on the ESA, and providing increased abundance of valuable sport and commercial fisheries. Benefits of the ERP will be achieved by working with local conservancies and watershed groups to restore the ecological processes associated with streamflow, stream channels, watersheds, and floodplains. Refer to the following documents for a thorough description of the CALFED Program and the ERP:

1) CALFED 1998. CALFED Bay Delta Program. Sacramento, California.
2) CALFED. 2000. CALFED Bay-Delta Program: Final Programmatic Environmental Impact Statement. Sacramento, California.
3) CALFED, 1999. CALFED Bay-Delta Program: Strategic Plan for Ecosystem Restoration. Sacramento, California.

The CALFED ERP presents restoration actions specific to the Battle Creek watershed and to Coleman NFH. These are:

- Improving fish passage facilities at Coleman NFH; and
- Improving hatchery management and release practices to protect genetic integrity of natural populations.

Implementation of CALFED ERP at Coleman NFH - Hatchery facilities and fish culture activities at the Coleman NFH are designed to minimize negative impacts on natural salmonid populations in Battle Creek. Working toward this goal, and in alignment with the specific restoration actions identified in the CALFED ERP, the Service is in the process of conducting the following projects: CALFED funding has recently been secured to modify the Coleman NFH barrier weir. Barrier weir modifications were designed to improve the existing upstream fish ladder, for the purpose of allowing improved monitoring and more effective management of passage into upper Battle Creek. Improved management of fish passage at the hatchery barrier weir will allow segregation of the various runs of chinook salmon at that location. The ability to segregate the runs of chinook salmon at the Coleman barrier weir will enable fishery managers to permit upstream passage for at-risk, priority stocks whereas more-abundant stocks can be restricted to the section of Battle Creek below the hatchery weir. The genetic integrity of naturally spawning salmonid populations in Battle Creek and elsewhere is further protected through implementation of refined protocols for broodstock selection, spawning, and juvenile release that are developed to reduce genetic risks to natural populations.

The Battle Creek Restoration Program

Program Overview - An agreement was recently reached between resource agencies, other stakeholders, and cooperators to restore approximately 42 miles of high-quality salmonid spawning and rearing habitats in the Battle Creek watershed. Restoration of the Battle Creek watershed is designed primarily to benefit ESA-listed "priority" species (winter and spring chinook salmon and steelhead trout), but will also benefit naturally-spawning fall and late-fall chinook salmon.

The intent to restore the Battle Creek watershed for naturally-producing salmonids while integrating artificial propagation activities at the Coleman NFH was formally advanced in a Service position paper (Wayne S. White, April 3, 1998; Attachment 3-2). Through implementation of the AFRP the Service has been a leader in planning, coordinating, and monitoring for the restoration project.

Alignment between the Battle Creek Restoration Program and Coleman NFH -
Because of its location on Battle Creek, facility operations at Coleman NFH are intimately linked to the Battle Creek watershed through two major operational requirements: 1) Battle Creek serves as the hatchery's sole water source; and, 2) Coleman NFH operates a barrier weir on Battle Creek to facilitate seasonal congregation and collection of broodstock. Facilities at Coleman NFH are being adjusted, when necessary, to align the hatchery with the restoration of natural salmonid populations in Battle Creek. Many of the restoration changes that have been completed or are underway at the hatchery are in direct alignment with actions described in the 1995 AFRP Working Paper and the Final AFRP plan (see AFRP references and Table 3-1). These changes, including modification of the hatchery barrier weir fish ladder, improvements to hatchery water intakes, and construction of an ozone treatment plant, are expected to directly benefit naturally producing anadromous salmonid populations in the Battle Creek watershed. Successful collaboration between the Service's Coleman NFH and Battle Creek Restoration efforts operations is critical to the overall success of the Battle Creek restoration program.

Table 3-1. Specific actions of the Anadromous Fish Restoration Program associated with hatchery operations or Battle Creek restoration. Items in bold are hatchery specific.

Action	Status
Continue to allow passage of adult spring and winter chinook salmon and steelhead above the Coleman NFH barrier weir.	Beginning in 2000, the upstream ladder in the Coleman NFH barrier weir has been open an additional two months.
Allow passage of fall, late-fall and passage of steelhead following development of disease-safe water supply for Coleman NFH	Ozone water treatment plant constructed and operational at Coleman NFH since 2001. Passage of additional steelhead since 1996. Passage of fall and late-fall chinook contingent on restoration of priority species.
Negotiate agreements to increase flows past PG&E hydropower diversions.	Ongoing/underway consistent with Battle Creek restoration project (see next section).
Construct barrier racks at Gover Diversion dam	Seasonal racks installed by CDFG
Screen Orwick Diversion	No Action
Screen tailrace of PG&E's Coleman Powerhouse tailrace	Temporary structure installed (2001). Funding acquired by USFWS from USBR to construct permanent modifications.

Coleman NFH Re-evaluation Process

To ensure that hatchery operations are managed such that they do not interfere with the watershed restoration program, the Service initiated a comprehensive review of Coleman NFH facilities, operations, and objectives; this review process is known as the Coleman NFH Re-evaluation Process. Four main objectives were identified for the Coleman NFH Re-evaluation process: 1) document the number of juvenile fish produced that have contributed to ocean harvest, in-river harvest, and adult returns to Coleman NFH; 2) determine mitigation responsibilities and the appropriate number of salmon and steelhead that need to be produced at Coleman NFH; 3) investigate potential effects of hatchery operations on naturally-produced salmon and steelhead; and, 4) describe ways the hatchery could meet its mitigation responsibilities while minimizing impacts on natural fish populations.

Private individuals, resource agencies, Battle Creek stakeholders, and other interested parties were invited to participate in the Coleman NFH Reevaluation process. Several public meetings were held, providing a forum to elicit concerns regarding potential impacts of the hatchery on natural salmonid populations, focusing on the Battle Creek restoration process. Over 50 alternative management strategies were generated to reduce or eliminate negative hatchery impacts, and alternative management strategies are currently being analyzed through a contract with an independent consultant (Harza Engineering; see Attachment 3-3 for scope of work and a list of management alternatives). A final report thoroughly evaluating the impacts and benefits of proposed management alternatives should be available in late 2001.

3.4 Direct effects of artificial propagation programs at Coleman and Livingston Stone NFH's on the restoration and recovery of listed species

Winter Chinook Salmon

The Coleman and the Livingston Stone NFH's fulfill important roles in fishery conservation and recovery for winter chinook salmon in the Sacramento River. A propagation program to supplement the endangered winter chinook salmon originated at Coleman NFH and is now conducted at Livingston Stone NFH. The Livingston Stone NFH was constructed for the explicit purpose of propagating endangered winter chinook salmon to assist in the recovery of that species. Hatchery-origin winter chinook salmon are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural population. In addition to the winter chinook propagation program, a captive broodstock program for winter chinook salmon is conducted by the Livingston Stone NFH and the BML.The goal of the winter chinook salmon captive propagation program is to provide short-term security against extinction for the at-risk population while environmental factors leading to their decline are corrected. In addition to providing a secure population to avert extinction, captive-reared winter chinook salmon may be used for mating, and their progeny may be released into the Sacramento River to integrate with the naturally spawning population. Both the winter chinook artificial propagation program and captive broodstock program are part of the NMFS's draft recovery plan for this endangered species (NMFS 1997).

Steelhead Trout

The Central Valley steelhead trout ESU will be directly affected by the artificial propagation program at Coleman NFH. Adult hatchery-origin steelhead trout from Coleman NFH are being used to re-establish a naturally spawning population in Battle Creek. The Service will investigate other potential uses of hatchery steelhead to promote recovery of natural populations in other locations.

Since 1995[1], adult hatchery-origin steelhead trout have been released above the Coleman barrier weir each year to spawn naturally in the upper reaches of Battle Creek. This action was initiated at the request of the CDFG following the development of an interim agreement with PG&E to increase flows in Battle Creek. Between 1999 and 2001, over 1,000 steelhead trout per year were passed upstream of the Coleman barrier weir to spawn naturally in the upper sections of Battle Creek. The Service proposes to continue to release hatchery-origin steelhead trout above the Coleman barrier weir to intermingle and spawn with naturally produced fish. Continuous integration between hatchery- and natural-origin steelhead in Battle Creek will ensure genetic integration between hatchery and natural stocks, and maximize the potential utility of Coleman steelhead for other recovery efforts. Furthermore, the release of mixed-origin adults into upper Battle Creek will promote maximum utilization of all suitable spawning habitats in the tributary. If only naturally produced steelhead were to be released above the Coleman barrier weir it is considerably more likely that suitable steelhead spawning habitats would be unutilized or underutilized.

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[1] Prior to 1995, hatchery-origin steelhead had occasionally been afforded access above the Coleman barrier weir, however, this strategy was not implemented on a yearly basis until that year.

3.5 Relationship of program to harvest objectives

In this section we estimate harvest and spawning escapement resulting from the chinook salmon propagation programs at Coleman and Livingston Stone NFH's. Harvest rates and numbers are estimated for contribution to the ocean commercial and sport fishery and the freshwater sport fishery. Spawning escapement is considered in regards to returns of adults to the hatchery facilities, natural spawning near to the hatchery facilities, and straying of adults to non-natal locations. We discuss in this section the recent phenomenon of dramatic over escapement of fall chinook adults to Battle Creek, and the effects of over escapement on Battle Creek Restoration. Estimates of harvest and escapement are presented for late-fall and winter chinook salmon, however, the focus of the discussion pertains to Coleman NFH fall chinook salmon. Fall chinook constitute the majority of our discussion because: 1) more data are available for assessing harvest and escapement of fall chinook salmon; and, 2) the fall chinook propagation program is much larger and, therefore, is of greater overall importance to the commercial and sport salmon fisheries. Scant information is available regarding harvest of steelhead trout; therefore, no discussion is presented herein.

Ocean contribution has been estimated for fall, late-fall and winter chinook salmon by brood year for 1989 through 1995. These data were generated by first obtaining expanded coded-wire recovery data for all marked groups during those brood years from the Pacific States Marine Fisheries Commission (PSMFC) Regional Mark Information System (RMIS) website at http://www.rmis.org (see Appendix 3A for data). Ocean harvest contribution rates were then generated for all CWT groups by dividing the number of expanded ocean recoveries by the number of marked juveniles in the release group. For production groups consisting entirely of unmarked juveniles, contribution rates from individual marked groups, or averages of marked groups, were applied by matching groups using criteria such as similar release site or similar release size.

Ocean harvest

We estimated total ocean harvest of fall and late-fall chinook salmon originating at Coleman NFH for brood years 1989 through 1995. Contribution of winter chinook salmon from Coleman NFH was examined for brood years 1991 to 1995 because marking and tagging of one hundred percent hatchery-origin winter chinook juveniles was not initiated until1991. Ocean harvest data were generated by obtaining expanded CWT recovery data from the PSMFC website for all marked groups released from Coleman NFH during those brood years. Ocean harvest rates were calculated for each tag code by dividing the number of expanded ocean recoveries by the number

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of marked juveniles released. For releases consisting of unmarked juveniles, harvest rates from individual marked groups or averages of marked groups occurring during the same brood year were applied by pairing groups of similar release site, release date, and fish size. Estimated ocean catch (rates and number contributed) for each release group of fall, late-fall, and winter chinook salmon from brood years 1989 through 1995 is presented in Appendix 3B and summarized by brood year in Table 3-2 and catch-year in Table 3-3.

Table 3-2. Number released, contribution by age, total contribution, and percent contribution to ocean harvest for brood years 1989 through 1995 for Coleman National Fish Hatchery fall, late-fall, and winter chinook salmon.

	Brood	Number	Contribution				Total	Percent
Run	**year**	**released**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**contribution**	**contribution**
Fall	1989	16,866,392	684	25,183	5,100	0	30,966	0.184
	1990	23,372,151	7,858	106,173	16,186	0	130,217	0.557
	1991	25,302,582	6,291	33,978	4,576	6	44,850	0.177
	1992	11,916,130	21,805	196,812	18,850	750	238,217	1.999
	1993	16,660,227	6,536	48,648	8,757	604	64,544	0.387
	1994	16,178,326	1,090	130,059	19,501	283	150,932	0.933
	1995	15,967,656	4,101	32,785	6,682	0	43,567	0.273
Average		126,263,464	48,364	573,636	79,651	1,642	703,293	0.557
		Age Structure	**6.9%**	**81.6%**	**11.3%**	**0.2%**		
Late-fall	1989	833,807	105	166	0	0	271	0.032
	1990	203,387	688	479	4	6	1,177	0.579
	1991	289,028	982	683	6	8	1,679	0.581
	1992	322,246	1,771	1,107	29	4	2,911	0.903
	1993	747,585	1,222	1,379	42	0	2,643	0.354
	1994	621,766	2,312	2,160	29	0	4,501	0.724
	1995	775,890	3,985	813	87	0	4,885	0.630
Average		3,793,709	11,064	6,787	197	19	18,067	0.476
		Age Structure	**61.2%**	**37.6%**	**1.1%**	**0.1%**		
Winter	1991	10,866	12	3	0	0	15	0.138
	1992	27,383	107	0	0	0	107	0.391
	1993	17,034	17	5	0	6	28	0.164
	1994	41,412	9	24	0	0	33	0.080
	1995	48,154	21	0	4	0	25	0.052
Average		144,849	166	32	4	6	208	0.144
		Age Structure	**79.8%**	**15.4%**	**1.9%**	**2.9%**		

Table 3-3. Contribution of Coleman National Fish Hatchery fall, late-fall, and winter chinook salmon to the ocean sport and commercial fisheries by catch-year for 1991-1999. Estimated contribution values in boxed areas and in bold were derived by utilizing the average percent contribution for each age class for catch-years, 1977-1997. Estimated contribution values in the boxed and shaded area were derived by averaging contribution of brood years 1973-1983 and 1989-1995, and multiplying the average percent contribution by age class by the number released.

Run	Catch-year	Contribution				Total
		Age 2	Age 3	Age 4	Age 5	contribution[a]
Fall	1991	684	**79,852**	**9,551**	**96**	**90,181**
	1992	7,858	25,183	**11,666**	**144**	**44,851**
	1993	6,291	106,173	5,100	**176**	**117,739**
	1994	21,805	33,978	16,186	0	71,970
	1995	6,536	196,812	4,576	0	207,923
	1996	1,090	48,648	18,850	6	68,594
	1997	4,101	130,059	8,757	750	143,666
	1998	**4,099**	32,785	19,501	604	**56,988**
	1999	**4,363**	**49,332**	6,682	283	**60,660**
	Totals	56,827	622,968	79,651	1,642	862,571
	Average	6,314	78,091	11,208	229	95,841
	SD	6,275	57,095	5,731	273	52,465
Late-fall	1991	105	**56**	**2**	**0**	**163**
	1992	688	166	**7**	**0**	**861**
	1993	982	479	0	**0**	**1,461**
	1994	1,771	683	4	0	2,458
	1995	1,222	1,107	6	6	2,341
	1996	2,312	1,379	29	8	3,728
	1997	3,985	2,160	42	4	6,191
	1998	**1,766**	813	29	0	**2,608**
	1999	**6,565**	**3,434**	87	0	**10,086**
	Totals	19,395	10,221	197	19	29,897
	Average	2,155	1,142	23	2	3,322
	SD	1,991	1,075	28	3	3,080
Winter	1993	12	0	0	0	12
	1994	107	3	0	0	110
	1995	17	0	0	0	17
	1996	9	5	0	0	14
	1997	21	24	0	0	45
	1998	0	0	0	6	6
	1999	0	0	4	0	4
	Totals	166	32	4	6	208
	Average	24	5	1	2	30
	SD	38	9	2	3	38

[a] Due to rounding error, values displayed in total column may differ from summation of age values.

Late-fall Chinook Salmon

The average contribution for late-fall chinook salmon for brood years 1989 through 1995 equals approximately 0.5%, with an annual average of 2,581 late-fall chinook salmon harvested in ocean commercial and sport fisheries (Table 3-2). At the current level of production (1,000,000 smolts annually), a harvest rate of 0.5% equals approximately 4,000 to 5,000 adults per brood year contributing to the ocean commercial and sport fisheries.

Harvest information from brood years 1989 through 1995 also shows that approximately 62% of the late-fall chinook harvested from a given brood year are age 2. This contrasts to fall chinook salmon where most of the fish harvested are age 3 (Table 3-2). Age 3, age 4, and age 5 comprise 36.7%, 1.2% and 0.1% respectively. Not shown are data demonstrating that some late-fall adults become vulnerable to the ocean harvest in the same year they are released.

By catch-year, an average of approximately 3,300 Coleman NFH late-fall chinook salmon were harvested in the ocean commercial and sport fisheries from 1991 to 1999 (Table 3-3).

Winter Chinook Salmon

Considered in terms of catch-year, an average of approximately 30 Coleman NFH winter chinook salmon were harvested in the ocean commercial and sport fisheries from 1993 to 1999. Despite generally increasing numbers of juveniles produced in the Coleman/Livingston Stone winter chinook salmon propagation programs, there has been a general decline in contribution to the ocean fishery by brood year since 1992 (Figure 3-1). This is likely the result of harvest restrictions implemented in the mid-1990's to protect endangered Sacramento River winter chinook and Klamath River fall chinook salmon. Based on ocean harvest recovery data, 107 adults from brood year 1992 were harvested in 1994 (Table 3-3). Since 1994, however, only 85 additional hatchery-origin winter chinook salmon have been harvested during the 1995 through 1999 seasons, despite increases in numbers of juveniles released.

The ocean contribution data presented for winter chinook salmon is significant because it has provided valuable information regarding ocean distribution and ocean exploitation rates for this endangered species. For example, based on the 1994 ocean harvest of 110 winter chinook salmon originating from Coleman NFH, the NMFS, through a Biological Opinion on the Pacific Fishery Management Council's (PFMC) 1996 Management Plan, imposed size restrictions to reduce the effect of ocean harvest on winter chinook salmon. Based upon our analysis of ocean harvest data, this regulatory action, combined with further harvest regulations designed to protect winter chinook and Klamath River fall chinook, have apparently been successful at reducing ocean harvest of winter chinook salmon

Considered in terms of brood year, an average of 42 winter chinook salmon from Coleman NFH were harvested in ocean commercial and sport fisheries from 1991 to 1995. The overall ocean harvest rate for Coleman NFH winter chinook salmon was approximately 0.15%. Age composition of ocean-caught winter chinook was 79.8% age-2, 15.4% age-3, 1.9% age-4, and 2.9% age-5 (Table 3-2).

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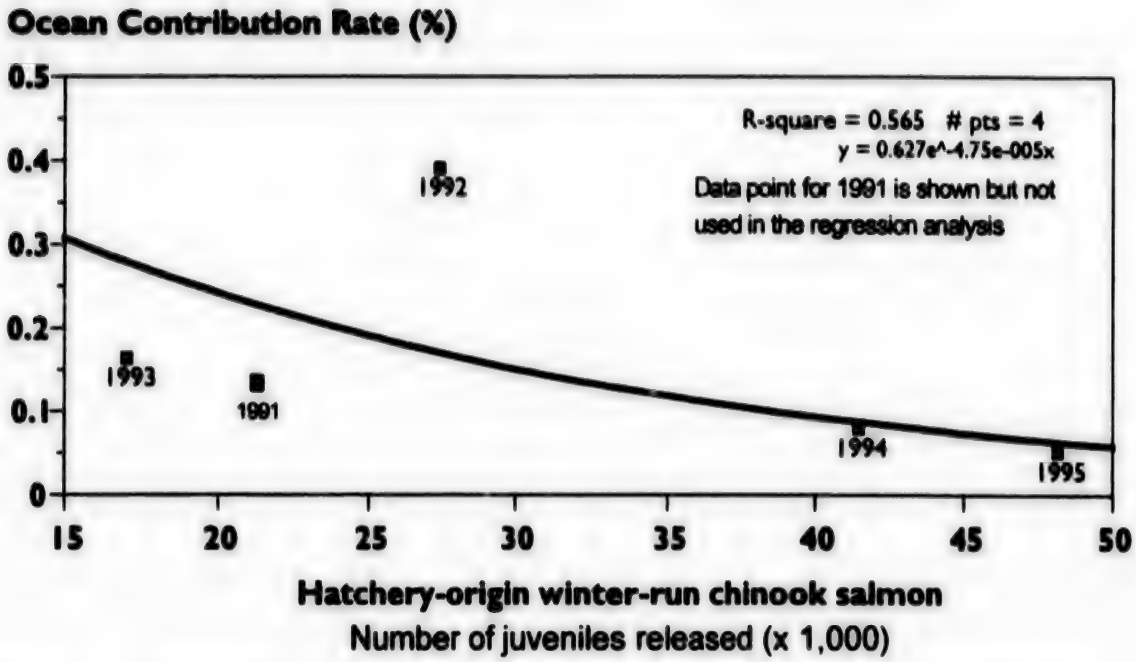

Figure 3-1. Ocean contribution rates of winter chinook salmon from Coleman National Fish Hatchery. brood years 1991 through 1995. Figure depicts general trend in decreasing ocean contribution values despite a general increase in the numbers of juveniles released in successive brood years.

Fall Chinook Salmon

We calculated ocean fishery contribution rates for fall chinook salmon from Coleman NFH from 1985 to 1995. For brood years 1989 through 1995, an average of 100,470 fall chinook salmon from Coleman NFH were contributed to ocean salmon fishery. This equates to an average ocean harvest (contribution) rate for Coleman NFH fall chinook salmon of approximately 0.6% (refer to table 3-2). Prior to brood year1989, coded-wire tag application strategies and numbers salmon coded-wire tagged at Coleman NFH were not appropriate to permit straight extrapolation of harvest rates to all untagged groups of fish. Estimates of fall chinook ocean harvest for the years preceding our investigation are from Cramer (1991) who completed a cohort reconstruction to estimate age-specific harvest rates from several hatcheries in the Central Valley, including Coleman NFH. Results of Cramer's analysis for brood years 1973 through 1985, in combination with our analysis covering brood years 1989 through 1995, provide a long-term (23-year) perspective on ocean harvest of fall chinook salmon originating at Coleman NFH (Tables 3-4 and 3-5).

Table 3-4. Estimated ocean contribution for fall chinook salmon from Coleman National Fish Hatchery by brood year (BY) based on number of salmon released. Estimated contribution values in the shaded area were derived by averaging contribution of BY 1973-1983 and BY 1989-1995 and multiplying the average percent contribution for each age class by the number released.

Brood	Number	Contribution				Total	Percent
year[a]	released	Age 2	Age 3	Age 4	Age 5	contribution[b]	contribution
1973	9,386,752	6,405	58,304	7,033	167	71,909	0.766
1974	2,497,280	120	4,102	726	5	4,953	0.198
1975	5,580,352	1,089	17,584	2,251	0	20,924	0.375
1976	9,791,842	2,190	16,307	598	42	19,137	0.195
1977	9,626,507	2,344	16,882	1,198	0	20,424	0.212
1978	5,704,562	285	6,677	1,140	21	8,123	0.142
1979	11,687,142	1,106	16,411	2,157	2	19,676	0.168
1980	14,494,691	2,585	9,860	729	19	13,193	0.091
1981	8,991,463	463	15,638	4,105	156	20,362	0.226
1982	17,035,983	523	62,716	19,180	21	82,440	0.484
1983	9,986,712	4,901	33,968	3,660	43	42,572	0.426
1984	23,424,330	4,901	46,469	5,711	[illegible]	[illegible]	[illegible]
1985	14,613,447	2,513	22,872	[illegible]	[illegible]	[illegible]	[illegible]
1986	11,802,158	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1987	18,152,003	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1988	22,172,654	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	16,866,392	684	25,183	5,100	0	30,966	0.184
1990	23,372,151	7,858	106,173	16,186	0	130,217	0.557
1991	25,302,582	6,291	33,978	4,576	6	44,850	0.177
1992	11,916,130	21,805	196,812	18,850	750	238,217	1.999
1993	16,660,227	6,536	48,648	8,757	604	64,544	0.387
1994	16,178,326	1,090	130,059	19,501	283	150,932	0.933
1995	15,967,656	4,101	32,785	6,682	0	43,567	0.273
Totals	321,211,322	93,549	1,069,154	163,255	2,836	1,348,793	0.420
Average	13,965,710	4,067	47,355	7,098	123	58,643	0.417
SD	6,060,323.66	4,575.72	45,594.30	6,128.02	193.42	54,682.52	0.40
	Age Structure	6.9%	80.8%	12.1%	0.2%		

a BY 1973-1985 data is from a cohort analysis by Cramer (1991). Data was extracted from Table 45.
BY 1989-1995 data is based on CWT ocean recoveries extrapolated to account for unmarked groups (USFWS, RBFWO unpublished data).

b Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3-5. Estimated ocean contribution for Coleman National Fish Hatchery (CNFH) fall chinook salmon by catch-year based on total ocean harvest. Estimated contribution values in the boxed and shaded area were derived by averaging contribution of catch-years 1977-1987 and catch-years 1994-1997 and multiplying the age class average percent contribution by the number released. Estimated contribution values in the boxed areas and in bold were derived by utilizing the average percent contribution for each age class for catch-years, 1977-1997.

	Contribution					Total	Percent
Catch-year[a]	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Totals**	**ocean catch**[b]	**CNFH Fall Chinook**
1975	6,405	68,762	**9,598**	170	**84,935**	327,100	26
1976	120	58,304	8,295	**134**	**66,853**	306,400	22
1977	1,089	4,102	7,033	197	12,421	340,400	4
1978	2,190	17,584	726	167	20,667	356,900	6
1979	2,344	16,307	2,251	5	20,907	342,600	6
1980	285	16,882	598	0	17,765	371,400	5
1981	1,106	6,677	1,198	42	9,023	363,700	2
1982	2,585	16,411	1,140	0	20,136	540,900	4
1983	463	9,860	2,157	21	12,501	231,200	5
1984	523	15,638	729	2	16,892	300,300	6
1985	4,901	62,716	4,105	19	71,741	334,100	21
1986	4,901	33,968	19,180	156	58,205	617,300	9
1987	2,513	46,469	3,660	21	52,663	599,700	9
1988	[illegible]	22,872	5,711	43	[illegible]	960,900	3
1989	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	497,700	11
1990	[illegible]	66,372	[illegible]	[illegible]	[illegible]	448,800	17
1991	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	316,700	28
1992	7,858	25,183	[illegible]	[illegible]	[illegible]	230,200	19
1993	6,291	106,173	5,100	[illegible]	[illegible]	359,000	33
1994	21,805	33,978	16,186	0	71,970	450,300	16
1995	6,536	196,812	4,576	0	207,923	1,020,100	20
1996	1,090	48,648	18,850	6	68,594	478,200	14
1997	4,101	130,059	8,757	750	143,666	687,100	21
1998	**4,099**	32,785	19,501	604	**56,988**	323,600	18
1999	**4,363**	**49,332**	6,682	283	**60,660**	n/a	n/a
Totals	102,011	1,207,248	181,148	3,337	1,493,743	10,804,600	
Average	4,080	48,290	7,246	133	59,750	450,192	14
SD	4,381	43,863	5,892	184	46,097	204,259	9
Age Structure	6.8%	80.8%	12.1%	0.2%			

a Catch-year 1975-1988 data is from a cohort analysis by Cramer (1991). Data was extracted from Table 45. Catch-year 1991-1995 data is based on coded-wire tag ocean recoveries extrapolated to account for unmarked groups (USFWS, Unpublished data).

b Ocean chinook landings South of Point Arena, taken from PFMC (1999). The ocean landings are inclusive of all chinook runs and do not include ocean chinook landings north of Point Arena. Due to rounding error, values displayed in total column may differ from summation of age values.

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An analysis of the long-term ocean contribution information reveals that an average of approximately 60,000 Coleman-origin fall chinook salmon were harvested in the ocean fishery annually between 1975 and 1999 (Table 3-5). During recent years, this long-term contribution average has been regularly exceeded. Between 1995 and 1999, an average of approximately 107,500 Coleman-origin fall chinook salmon were harvested in the ocean commercial and sport fisheries each year. The lowest harvest occurred in 1981, when approximately 9,000 were caught, while the highest harvest occurred in 1995 when approximately 208,000 were landed. Recent analyses demonstrate that much of this contribution is attributable to smolt releases, as fall chinook salmon fry typically have low contribution rates when compared to smolts (see Appendix 3C for a comparative analysis of fry vs. smolt contribution). The Service discontinued the practice of releasing Coleman NFH fall chinook fry in 1999.

From brood years 1975 through 1999, the maximum harvest of Coleman-origin fall chinook salmon in the ocean fishery was for brood year 1992 when approximately 238,000 were caught (Table 3-4), primarily as 3-year olds in 1995 (Table 3-5). This contribution resulted primarily from a release of about 12,000,000 smolts and was the highest recorded contribution rate for Coleman NFH fall chinook at nearly 2.0%. This value is over ten times greater than the contribution demonstrated by the previous brood year (1991; 0.18%), and approximately double the next closest value (brood year 1994; 0.93%). Brood year 1974 contributed the least fish to the ocean fishery (5,000 fall chinook salmon); however, in that brood year only 2.5 million fall chinook salmon were originally released.

To put these harvest estimates of Coleman-origin fall chinook salmon into perspective, it is helpful to look at them as a percentage of California's ocean harvest. Ocean harvest south of Point Arena makes up approximately 85-95% of California's total salmon harvest. For the years 1975 through 1998, fall chinook salmon from Coleman NFH constituted approximately 14% of total harvest south of Point Arena. For catch-years 1990 through 1998, average annual contribution of Coleman-origin fall chinook south of Point Arena averages approximately 20% (sd = 8.9). For all years, age-3 fall chinook dominated the ocean catch. The overall breakdown by age was 6.8% age-2, 80.8% age-3, 12.1% age-4, and 0.2 % age-5.

Freshwater harvest

Fall Chinook Salmon

Freshwater harvest and spawning escapement were estimated for fall chinook salmon originating at Coleman NFH. To generate these estimates, we began with estimates of Battle Creek escapement (Grand Tab, CDFG, Red Bluff, CA) and back-calculated to estimate freshwater harvest and natural-spawning escapement in the following manner:

1) **Total Battle Creek Escapement:** Hatchery returns + natural spawners

2) **Coleman NFH Contribution:** 0.9 x Total Battle Creek Escapement (CDFG 1994 in CH2M Hill 2001)

3) **Strays:** Based on Total Battle Creek Escapement and estimated separately for groups released at different locations and at different life stages. (see Straying Analysis–Appendix 10C)

4) **Total Upriver Escapement:** (Coleman NFH Contribution) / [(1) - (Freshwater Harvest rate - see below)]

5) **Freshwater Harvest:** [(Total Upriver Escapement) - (Coleman NFH Contribution)] + (Strays)

Cramer (1991) estimated freshwater sport fishing harvest of fall chinook salmon was approximately 5% of the total freshwater escapement from 1975 through 1988. More recently, PFMC (1999) estimated an in-river harvest rate of 25% for the years 1991 through 1994. This estimate is in alignment with the 1998 creel-survey harvest estimate for fall chinook salmon conducted by the CDFG (Murphy et al. 1999). We applied Cramer's estimate to years 1975 through 1987, and PMFC's estimate to years after 1990. Freshwater harvest for the three intervening years (1988, 1989, and 1990) was estimated at 15% by applying the average of the Cramer and PFMC estimates.

Based on these methodologies, we estimate 30,000 Coleman NFH fall chinook salmon were harvested annually in the Sacramento River sport fishery from 1995 to 1999 (Table 3-6). Over the past 24 years, average freshwater harvest was approximately 9,000 per year with the low of 501 in 1978 and a high of 35,000 in 1999.

Table 3-6. Estimated harvest and escapement of fall chinook salmon raised at Coleman National Fish Hatchery (NFH), 1975-1999.

	Escapement[a]						
Year	Lower Battle Creek	Coleman NFH	Upper Battle Creek	Freshwater harvest[b]	Ocean harvest[c]	Estimated strays[d]	Total
1975	2,183	2,188		1,283	84,935	20,003	110,592
1976	2,832	2,067		1,012	66,853	14,324	87,088
1977	5,044	4,720		658	12,421	2,740	25,582
1978	1,593	1,694		501	20,667	6,231	30,686
1979	3,987	7,856		930	20,907	5,820	39,500
1980	4,446	8,553		780	17,765	1,813	33,356
1981	6,240	9,245		848	9,023	629	25,985
1982	6,543	17,573		1,318	20,136	928	46,498
1983	4,704	7,880		707	12,501	839	26,631
1984	7,481	19,423		1,518	16,892	1,935	47,249
1985	11,513	14,688	9,626	2,077	71,741	3,645	113,291
1986	10,357	11,233	6,537	1,767	58,205	5,442	93,541
1987	5,281	14,630	1,913	1,415	52,663	5,055	80,957
1988	46,731	12,221	1,776	12,538	32,194	10,319	115,778
1989	16,946	10,787	210	5,423	55,867	2,788	92,021
1990	5,808	13,172		3,925	78,402	3,262	104,568
1991	5,902	9,615		5,823	90,181	1,953	113,474
1992	4,860	6,548		5,745	44,851	5,798	67,831
1993	9,926	6,828		9,746	117,739	12,485	156,725
1994	21,847	17,092		16,545	71,970	10,696	138,149
1995	50,864	24,009		28,502	207,923	10,635	321,933
1996	47,164	19,060		24,296	68,594	6,664	165,777
1997	45,669	45,603		33,672	143,666	9,743	278,352
1998	48,561	39,916		32,098	56,988	7,817	185,381
1999	83,654	24,273		35,976	60,660	n/a	204,562
Totals	460,165	350,873	20,061	229,101	1,493,743	151,563	2,705,506
Average	18,407	14,035	4,012	9,164	59,750	6,315	108,220
SD	21,820	10,703	3,929	11,935	46,097	4,899	77,448

a Modified to 90% of Grand Tab tables-California Department of Fish and Game as per CDFG (1994 in CH2M Hill 2001).

b Calculated values:
1975-1987 Based on 5% of escapement from Cramer (1991).
1988-1990 Based on 15% of escapement which is an average of Cramer (1991) and PFMC (1999).
1991-1994 Based on 25% of escapement from PFMC (1999).
1995-1999 25% of escapement based on previous years.

c From Table 3-5.-Estimated ocean contribution for Coleman NFH fall chinook salmon by catch-year, 1975-1999.

d Estimated strays include salmon that were harvested after straying. Data from 1975-1987 are taken from Cramer (1991). Data from 1988-1999 are estimated from Battle Creek and Coleman NFH contribution by release group and associated stray index (%) by life stage at release and release site (see discussion of stray rates in Appendix 10C).

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3.6 Escapement to Battle Creek

The number of hatchery-origin fall chinook salmon from Coleman NFH escaping to the spawning grounds has shown an increasing trend and has exceeded broodstock requirements at the hatchery since the early 1990's. Spawner escapement of fall chinook salmon to Battle Creek from 1953 through 1991, including AFRP baseline period 1967 - 1991, averaged approximately 17,000 adults (Figure 3-2). During more recent years, substantially more fall chinook salmon have returned to Battle Creek, with an estimated average of 87,000 hatchery-origin fall chinook salmon escaping to Battle Creek from 1994 to 1999.

Escapement of fall chinook salmon to Coleman NFH has generally exceeded broodstock collection requirements since the late-1970's (Figure 3-2). The trend of substantial over-escapement to the hatchery, however, is very recent. Spawner requirements at current production levels at Coleman NFH are approximately 6,400 adults (generally 60% male and 40% female). To obtain the required number of broodstock over 8,000 adult fall chinook must be collected. Collection of adults in addition to spawner requirements is conducted to buffer for gender inequity and pre-spawn mortality (>5%), and to obtain sufficient numbers of spawners at the tails of the spawning distribution to form a normal, bell-shaped spawning distribution. As recent as 1992, only 11,500 adults returned to Battle Creek.

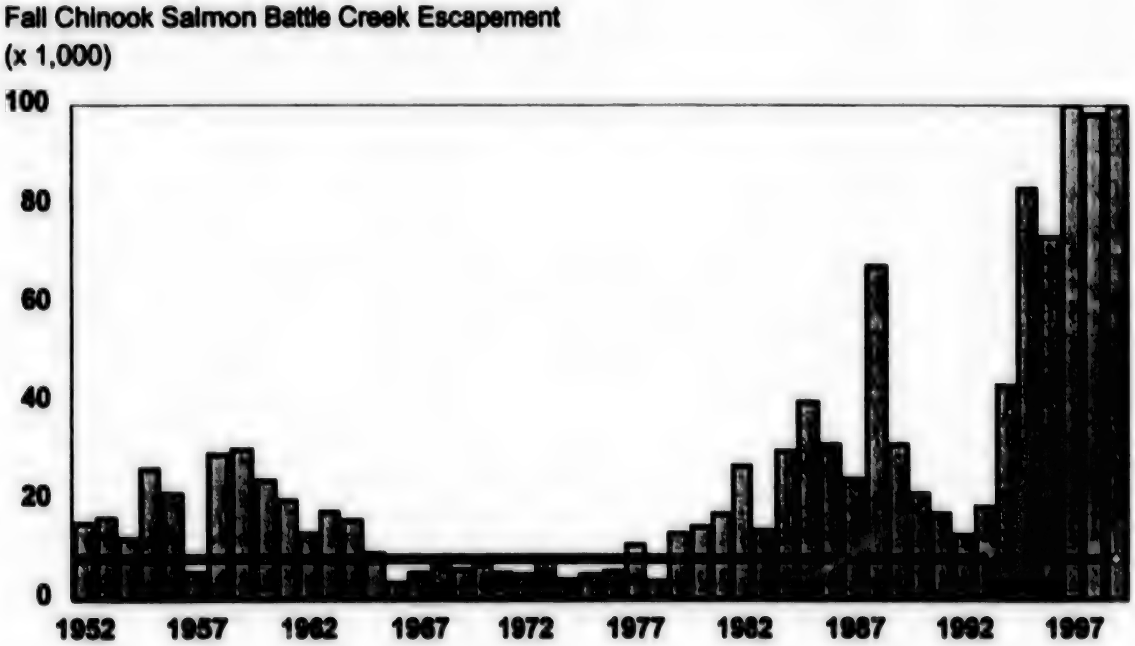

Figure 3-2. Escapement of fall chinook salmon to Battle Creek from 1952-1999 (source California Department of Fish and Game GrandTab). Escapement includes both adults taken into Coleman National Fish Hatchery and adults spawning naturally in Battle Creek. Heavy black line denotes broodstock collection requirement (approximately 8,000) for fall chinook salmon at Coleman National Fish Hatchery.

3.7 Impacts of hatchery-origin salmonid (over) escapement on Battle Creek Restoration

Fall Chinook Salmon

Over-escapement of fall chinook salmon to Battle Creek during recent years, in concert with substantial efforts to restore the Battle Creek watershed for natural producing salmonids, has focused attention on hatchery-origin fall chinook salmon as a potential threat to Battle Creek restoration. Conflicts may arise from: 1) spatial limitations of spawning habitat, causing increased competition for redd sites or redd superimposition; 2) disease transmission; 3) negative effects to emigrating juveniles caused by hatchery-origin fall chinook salmon; or, 4) genetic concerns related to hatchery-natural interbreeding.

Spatial Limitations of Spawning Habitat and Genetic Concerns

We examined potential conflicts between Battle Creek restoration and the recent trend of fall chinook salmon over-escapement to Battle Creek (see Appendix 3D). In this analysis, we provide evidence to suggest that over-escapement of fall chinook salmon has not reduced productivity in Battle Creek due to competition for redd sites or redd superimposition, and will not likely risk the genetic fitness of the naturally-spawning population (also see Appendix 6D for a discussion of genetic risks from hatchery propagation). In fact, other studies (e.g., Bilby et al. 1996, Cedarholm et al.1999, Wipfli et al. 1999) have shown that significant biomass from adult carcasses may enhance ecosystem function by providing marine-derived nutrients which can increase overall productivity in a system.

Disease Transmission

There is no indication of disease transmission from adult carcasses to natural-origin chinook salmon in Battle Creek. No IHNV was detected in naturally-produced fall chinook fry collected from Battle Creek, despite their close proximity to IHNV-infected adult carcasses (Foott 1996b). Furthermore, no IHNV-infected juveniles of natural-origin have been collected from the Sacramento River despite close association with IHNV-infected carcasses (S. Foott, pers. comm.). The Service, through the CA-NV FHC, plans to continue monitoring naturally-produced juvenile salmonids in Battle Creek and the upper Sacramento River for diseases.

Although transmission of IHNV from carcasses to juvenile salmonids in Battle Creek has not been demonstrated, disease transmission via this mode remains a concern of the Service. In response to this concern, the Service will investigate the feasibility of culling additional adult fall chinook salmon at Coleman NFH during years of substantial over-escapement to reduce the possibility of disease transmission and other possible deleterious effects posed by large numbers of returning hatchery fish.

Negative Effects on Emigrating Juveniles

Natural-origin juvenile salmonids emigrating during the months of October through November could be negatively affected as they emigrate through large congregations of hatchery-origin fall chinook salmon in lower Battle Creek. Negative impacts could occur as stress, alteration of migratory patterns, or predation.

While it is possible that juvenile salmonids are negatively impacted as they emigrate through large congregations of adults, we have no data to support nor refute this speculation. Monitoring of juvenile emigration patterns in Battle Creek from 1998 through 2000 has shown that very few salmonids emigrate from Battle Creek during October or November (see Appendix 10D for timing and estimated passage of emigrating juvenile salmonids), limiting the severity of any potential impact. Continued and increased monitoring of juvenile emigration patterns in conjunction with adult abundance estimates will be necessary to determine the existence and degree of impact.

Late-fall Chinook Salmon

Numbers of late-fall chinook salmon collected at Coleman NFH ranged between 1,300 and 6,000 adults from 1996 to 1999. To accomplish production goals, less than 1,000 adults are required for broodstock. The number of late-fall chinook spawning naturally in Battle Creek is unknown, but presumably small, as most late-fall adults are thought to enter into the hatchery. This level of late-fall chinook salmon escapement should not constitute a risk to Battle Creek restoration.

Winter Chinook Salmon

Escapement estimates for hatchery-origin winter chinook salmon returning to the upper Sacramento River and Battle Creek are 88, 237, and 266 for the years 1995 through 1997, respectively. Escapement of hatchery-origin winter chinook salmon to Battle Creek is expected to cease after the year 2000 because hatchery-origin juvenile salmon have been reared and released exclusively on the mainstem Sacramento River since brood year 1998.

Steelhead Trout

Current escapement levels for steelhead trout should not constitute a risk, but are considered by the Service to benefit restoration of a steelhead populations in Battle Creek. Because returns of adult steelhead to Coleman NFH typically range between 1,000 and 4,000, and less than 600 spawning adults are actually required for broodstock, excess hatchery steelhead are available to assist in restoration efforts. Since 1996, adults in excess of broodstock needs have been passed above the Coleman barrier weir to spawn naturally and recover a natural population in Battle Creek.

3.8 Relationship of harvest and escapement

California's coastwide ocean harvest effort decreased 18% from 1997 to 1998, resulting in a level 80% below the 1986 to 1990 average. From 1997 to 1998, the active commercial fleet decreased by 176 vessels (21%). For the ocean recreational fishery, angler effort in 1998 decreased 35% from 1997 and was 23% below the 1976 to 1997 average. On a percentage basis, the decline of fishing effort was greatest for California's northern port areas (north of Fort Bragg), but in terms of numbers the greatest declines were in the ports of San Francisco and Monterey. San Francisco and Monterey are the major salmon fishing ports south of Point Arena, where harvest is comprised predominantly of fall chinook salmon originating in the Sacramento River system.

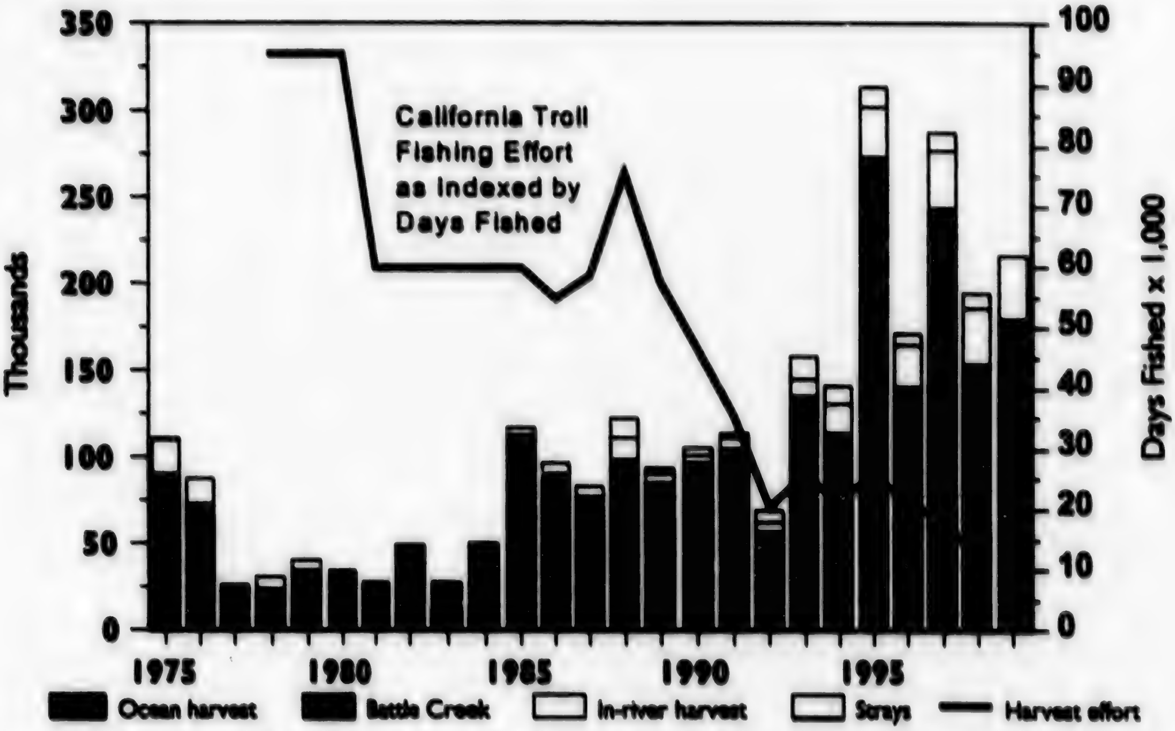

Figure 3-3. An index of survival for Coleman NFH fall chinook salmon, consisting of estimated ocean and in-river harvest, estimated escapement to Battle Creek and Coleman NFH, and estimated strays, for years 1995 through 1999. The total number of days (x1,000) fished (California ocean troll) is also plotted as an index of fishing effort (PFMC 1999).

Although fishing effort has generally decreased during recent years, ocean harvest estimates for Coleman NFH fall chinook salmon have been stable or have increased slightly (Figure 3-3). Since 1975, ocean harvest of Coleman-origin fall chinook salmon has averaged nearly 60,000 adults annually. More recently, from 1995 to 1999 an average of approximately 107,500 Coleman-origin fall chinook salmon were harvested annually in California's ocean salmon fisheries.

With smolt production of fall chinook salmon relatively constant at 11 to 13 million per year (1988 to present), the increase in harvest numbers, concomitant with decreased fishing effort and increased freshwater escapement (see Sections 3.6 on escapement) suggests a substantial increase in overall survival of Coleman NFH fall chinook salmon since the early 1980's (Figure 3-3). Yoshiyama et al. (2000) also report a trend of increasing annual escapement to the Sacramento-San Joaquin system. From 1992-1994 and 1995-1997, average freshwater escapement estimates in the upper Sacramento River basin increased by 150% (PSMC 1998 in Yoshiyama et al. 2000). The authors attributed this trend to a change of precipitation patterns in the Central Valley, with a transition from the drought years of 1988-1992 to the recent wet cycle. However, other researchers have suggested that cycles of ocean productivity may also play a role. For example, some researchers have suggested that Pacific salmon stocks adhere to decadal or multi-decadal shifts in abundance that are influenced by 20-30 year-long regimes of prevailing oceanic conditions (Hare et al. 1999). Hare et al. (1999) describe a phenomenon named the Pacific Decadal Oscillation, a recurring pattern of Pan-Pacific atmosphere-ocean variability, that they believe has created long-term cycles of favorable and unfavorable oceanic conditions. They report that from 1977 to the early 1990s, ocean conditions generally favored Alaskan stocks and disfavored West Coast stocks.

Impacts of a Mixed-stock Fishery

Mixed stock fisheries present complex problems for fishery regulatory agencies (e.g., setting appropriate fishing regulations and harvest levels) and hatchery production programs (determining production levels). Hatchery populations can generally sustain substantially higher rates of harvest as compared to natural populations. This occurs because mortality associated with spawning and rearing is substantially reduced in hatcheries compared to natural environments. A result of these differences in production rates is that relatively fewer adults are required to produce a sustainable rate of hatchery recruitment as compared to natural recruitment, and, therefore, the hatchery stock can generally sustain substantially higher exploitation rates. When fishing effort is set at a level compatible with the more-productive component of the population, overfishing of the less-productive (i.e., "weaker") component is a likely outcome. Alternatively, fishing regulations are sometimes implemented to protect weaker stocks of a mixed-stock fishery. For example, restrictions of commercial fishing seasons off the California coast were implemented in the mid-1990's to protect imperiled stocks of Sacramento River winter and Klamath River fall chinook salmon. An unintended consequence of restricting fishing effort to protect weak stocks can be underutilization of the more-productive hatchery stocks, leading to substantial surplus adults returning to the hatchery. These situations describe what is commonly referred as the mixed-stock fishery dilemma.

Since 1995, escapement of fall chinook salmon to Battle Creek has substantially exceeded hatchery broodstock requirements (see Figure 3-2), suggesting possible effects from recent harvest restrictions. Upon further review of the situation, however, it is apparent that factors other than reduced harvest alone have lead to over-escapement of fall chinook salmon to Coleman NFH. Examination of harvest and escapement data going back 25 years reveals substantially increased rates of freshwater escapement and relatively stable ocean harvest rates coinciding with substantially reduced fishing effort (see Figure 3-3). Considered together, this information suggests substantial increases in survival of fall chinook salmon from Coleman NFH. We speculate that the recent survival increases may be related to favorable conditions during freshwater rearing or long-term cycles of ocean productivity, and are not necessarily a consequence of only fishing restrictions alone.

In response to recent over-escapement in Battle Creek, it has been suggested that the Service decrease production of fall chinook salmon at Coleman NFH. The Service is not opposed to considering this; however, any decrease of production of sufficient magnitude to avoid surplus escapement to Battle Creek, given inherent variation in environmental conditions, could result in substantial decreases in abundance and harvest. This point can be illustrated using a model developed by the Service to predict ocean and freshwater harvest, returns to Battle Creek, and strays as a function of the number of fall chinook salmon released from Coleman NFH (Appendix 3E). This model is based on recent estimates of harvest and freshwater escapement of fall chinook salmon, and can be used to predict impacts on harvest and escapement resulting from increases or decreases in juvenile (smolt) production of fall chinook salmon.

For example, using the current production target of 12 million fall chinook salmon smolts, between 27,000 and 220,000 adults are expected to contribute to the ocean harvest (average = 90,000) assuming fishing effort remains constant. At this release level we also expect 14,000 to 110,000 adults escaping to Battle Creek, while an additional 3,000 to 28,000 would be expected to contribute to in-river harvest. It is apparent that inter-annual survival, and therefore escapement, varies greatly even with relatively constant production. Since survival in the hatchery is relatively constant, this variation in survival is likely related to changes in environmental conditions.

Stock-recruitment functions, which have traditionally been employed to determine escapement goals in mixed stock fisheries, were determined by the National Research Council (1996) to be "inherently uncertain" and available data are seldom sufficient to justify the escapement goals produced through this analysis. The stock-recruitment relationship is largely influenced by the degree of environmental variability, and little information is available to predict levels of annual variability and effects on salmonid survival, especially in marine environments (NRC 1996). Without the ability to predict environmental conditions, and to relate those conditions directly to salmonid survival, hatchery managers will not be able to tailor production levels to escapement goals on an annual basis.

HATCHERY WATER SOURCE

4.1 Coleman National Fish Hatchery

Water Intakes

Battle Creek is the source of water for all fish culture activities at Coleman NFH. Three intake structures and associated conveyance facilities are used to divert and convey water directly from Battle Creek and the Coleman Powerhouse tailrace (Figure 4-1).

The hatchery's primary intake (Intake 1) is located in the tailrace of Pacific Gas and Electric's (PG&E) Coleman Powerhouse, on the north bank of Battle Creek. The tailrace empties into Battle Creek approximately 1.6 miles upstream of the hatchery property. Water taken through Intake 1 is conveyed to the Coleman Canal by a 46-inch diameter conveyance pipe.

Coleman NFH Intake 2 is located on the south bank of Battle Creek, opposite of Intake 1. Intake 2 draws water directly from Battle Creek, and is used as an emergency back-up to Intake 1. The design of Intake 2 prevents diversion of water simultaneous with Intake 1. Intake 2 supplies water to the hatchery only during periods when water cannot be supplied through Intake 1 (e.g., failure of canal or powerhouse maintenance). Over the last ten years of operations, the average amount of time that hatchery water could not be supplied through Intake 1 was 412 hours (17.2 days) annually. Intake 2 shares the 46-inch conveyance pipe with Intake 1.

Intake 3 draws water directly from Battle Creek, approximately 0.4 miles downstream of Intake 2, and 1.2 miles upstream of the hatchery. Water diverted through Intake 3 is conveyed to the hatchery through 4,600 feet of 48-inch diameter pipeline.

Water from all three intakes can be shunted to the ozone water treatment facility or sent directly to various fish rearing areas at Coleman NFH. Intakes 1 and 2 are used primarily to supply the twenty-eight 15-foot x 150-foot raceways at Coleman NFH. Intake 3 is used primarily to supply the thirty 8-foot x 80-foot raceways and the hatchery's incubation and early-rearing building. Additionally, the water delivery system at Coleman NFH has numerous piping interconnections between facilities. These interconnections allow water to be diverted from the canal to the sand traps, to bypass the water treatment system, and to be reused from the 15-foot x 150-foot raceways to the 8-foot x 80-foot raceways. A complete description of the existing water delivery system at Coleman NFH can be found in *Coleman National Fish Hatchery, California: Intake Alternatives Study* (Sverdrup and Tetra Tech/KCM, Inc. 1999).

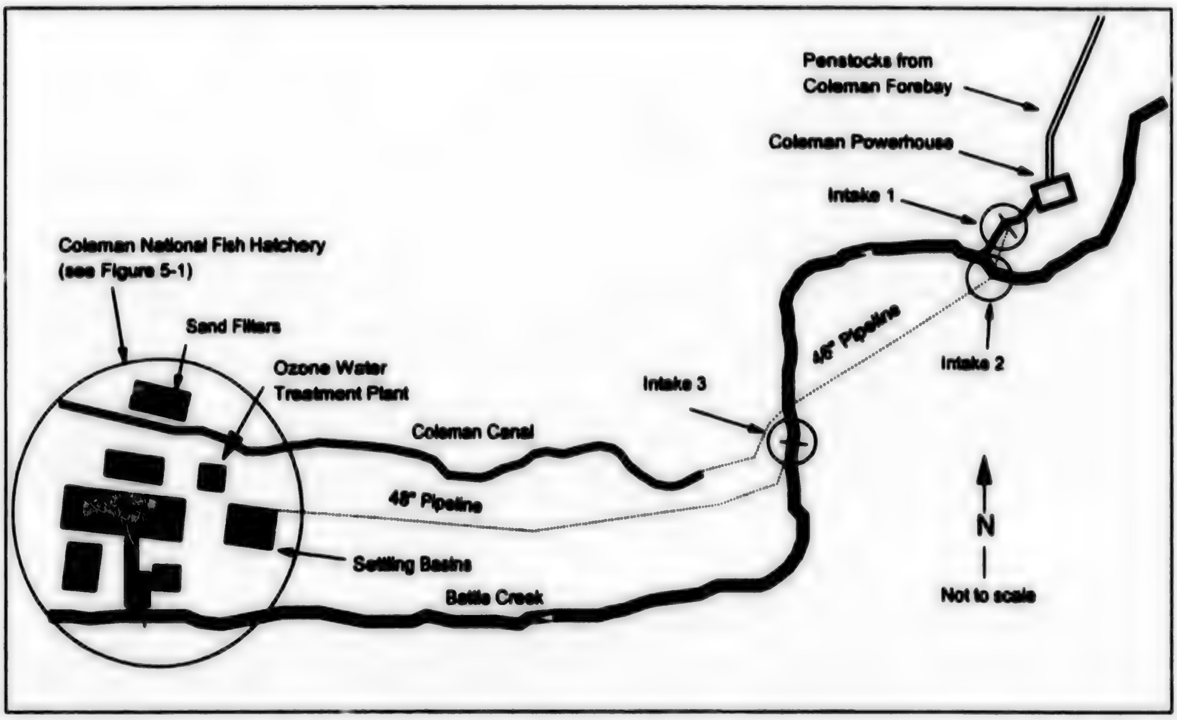

Figure 4-1. Existing water diversion and delivery system at Coleman National Fish Hatchery, Battle Creek, California.

The water delivery system and water treatment plant at Coleman NFH are equipped with numerous alarms to alert hatchery staff in the event of power outages or low water supply. On-station housing increases the likelihood that one or more employees will be on-site to respond to emergencies occurring during non-business hours.

Intake Screening: Integration with Battle Creek Restoration
To successfully integrate Coleman NFH with Battle Creek restoration the hatchery's water supply must be properly screened to avoid diversion, entrainment, and impingement of naturally-produced juveniles. Proper screening of Coleman NFH diversions is a high priority of the Service. The AFRP (USFWS 2001) directs the Service to "prevent attraction of adult chinook into the powerhouse tailrace, and screen the intakes to prevent entrainment of juvenile salmonids."

Until recently the Coleman NFH operated with unscreened intakes. During 1998, interim intake upgrades were implemented to reduce fish entrainment. The current status of intake screening is as follows:

Intake 1. Coleman NFH Intake 1 is not screened, however, water entering Intake 1 originates from the upper reaches of Battle Creek (Inskip Powerhouse), an area which is currently inaccessible to anadromous fish, and therefore Intake 1 does not pose a threat for "take" of listed salmonids.

Intake 2. A flap gate at Intake 2 serves to block this unscreened intake except under emergency conditions. Intake 1 and Intake 2 cannot operate at the same time.

Intake 3. In the fall of 1998, a smaller-mesh, emergency, removable, perforated-plate fish screen was added to Intake 3. In addition, an experimental stream-bed mounted auxiliary fish screen was constructed at Intake 3 This screen has subsequently been removed due to inadequate reliability.

The existing (interim) intake structures for the Coleman NFH do not meet NMFS "fail-safe" screening criteria. Because of the deficiencies of the existing intake screens, the Service conducts periodic salvage operations to rescue fishes entrained in the hatchery's water delivery system. Salvage protocols were developed in consultation with NMFS, and are summarized below:

> Salvage efforts are conducted both in the Coleman NFH water delivery canal (to rescue fishes diverted through Intake 2) and the settling basins (to rescue fishes diverted through Intake 3). Fish rescue is conducted by a variety of methods including seining, angling, dip nets, cast nets, and electroshocking. The timing of salvage operations is limited to periods when the hatchery's water needs are reduced. For example, salvage of fishes entrained in the Coleman canal is limited to May when the hatchery's water demand is low and can be fully supplied by Intake 3. Salvage of fishes in the hatchery's settling basins requires draining the basins, and therefore must be conducted when Intake 3 is not in use. Results of fish salvage operations conducted during 1999 and 2000 are presented in Attachment 4-1.

All existing water intakes for Coleman NFH are currently under evaluation for modification in conjunction with Battle Creek restoration efforts. In the future, all water entering the PG&E canal system will be screened with structures meeting NMFS "fail-safe" screening criteria (February 1999 MOU among NMFS, USBR, USFWS, CDFG, and PG&E). In 1998, discussions were initiated to determine a long-term solution for the Coleman NFH water delivery system, emphasizing water supply reliability and protection of all naturally-produced fish. A technical subcommittee of the BCWG, including representatives of the resource agencies (NMFS, CDFG, USBR, and USFWS) and design engineers, was formed to resolve issues associated with Coleman NFH's unscreened diversions. Ten potential alternatives were developed by this subcommittee and each alternative was assessed in terms of its applicability to eight criteria: water quality and quantity, system reliability, redundancy, access, fish protection, maintenance, long term performance, and water rights (Sverdrup and Tetra Tech/KCM, Inc., 1999). The list of potential alternatives was subsequently narrowed to four feasible alternatives through a process known as "value engineering" (Sverdrup and Tetra Tech/KCM, Inc., 1999). Recently, an additional alternative (Alternative 11) was presented by the Battle Creek Watershed Conservancy. With the addition of a new intake alternative, a new analysis is underway to rank the potential alternatives prior to beginning the National Environmental Policy Act (NEPA) process.

Water Rights

The Service holds Battle Creek water rights for up to 122 cubic feet per second (cfs) to conduct fish propagation activities at Coleman NFH (Table 5-1; USFWS 1987). Coleman NFH water rights were obtained by appropriation. Legal descriptions of water rights owned by the Government are as follows (Luken et al. 1981): Water rights covered in Contract 149r-1070, dated October 5, 1942, between Gover and the United States, and Contract 149r-1079, dated September 25, 1942, between Taylor and the United States.

Table 4-1. Coleman National Fish Hatchery Water Rights on Battle Creek (Service 1987).

Appropriation Number	Permit Number	License Number	Priority Date	ft^3/s	Purpose
13540	8838	4472	01/12/50	61	Fish Culture
17862	11615	6591	10/25/57	11	Fish Culture
20288	13384	7993	07/03/61	30	Fish Culture
22277	15046	9561	07/19/65	20	Fish Culture
Total				122	

Water Treatment Facility

Disease and sediment problems associated with the water supply have confounded fish culture programs at Coleman NFH since its inception. High sediment loads, generally associated with high flow events in Battle Creek, have caused mortality of juvenile and adult salmonids at the hatchery. Likewise, recurrent disease outbreaks possibly associated with the hatchery water supply have resulted in increased mortality of juveniles (see Foott and Williamson 1997). More than ten significant pathogens have been detected in salmonids at Coleman NFH (Foott 1996).

To reduce sediment in the hatchery water supply and to alleviate recurrent disease problems, a water treatment facility capable of filtering 45,000 gallons per minute (gpm) and ozonating 30,000 gpm has recently been constructed at Coleman NFH. Several documents thoroughly discuss the justification, selection, and construction of the ozone water treatment facility at Coleman NFH (USFWS 1986, USFWS 1987, USFWS 1989, USFWS 1997a, USFWS 1997b). Operation of the ozone water treatment facility is expected to substantially lessen the occurrence of disease in hatchery production and reduce the potential for disease transmission to naturally-produced stocks. In fact, the ozone facility reached full capacity in 2000, and juvenile fall chinook from brood years 1999 and 2000 have been reared and released with no incidence of IHNV. This is a first in the history of the hatchery.

Water Discharge

Water use at the Coleman NFH is non-consumptive. All water diverted from Battle Creek for use at Coleman NFH is returned to the creek through an overflow channel, the fish ladder, a separate wastewater ditch, or the outfall of the pollution abatement pond. The total distance over which water is diverted is 1.2 miles (from Intake 3) to 1.6 miles (from Intakes 1 and 2). The facility discharges an average of 40.8 million gallons per day (mgd). Approximately 3.3 mgd of hatchery wastewater is diverted through the pollution abatement pond prior to discharge into Battle Creek. The pollution abatement pond is used primarily to reduce the discharge of solids (i.e., fish fecal material, unconsumed food, algae, and silt) associated with raceway cleaning.

All water discharged from the Coleman NFH is regulated by National Pollution Discharge Elimination System (NPDES) permit (Attachment 4-2) issued by the California Regional Water Quality Control Board (WQCB). As a provision of this permit, the Service conducts monthly sampling of total suspended solids, pH, dissolved oxygen, turbidity, and temperature in both supply- and receiving-waters in Battle Creek. The permit also covers chemicals used for fish health maintenance and treatment at the hatchery (e.g., formalin, antibiotics). In issuing the NPDES permit, the WQCB concluded that discharge at the Coleman NFH is considered "minor," and existing wastewater treatment technology (such as the settling pond) "...is capable of consistently reducing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or ground water are adversely affected." "Beneficial uses" include "preservation and enhancement of fish, wildlife, and other aquatic resources."

Negative impacts to naturally producing salmonid populations and their habitats associated with water discharge from Coleman NFH are considered to be minimal (none to low) for two reasons. First, the determination by the WQCB indicates that discharge should not adversely affect beneficial uses of surface or ground water. Second, the operation of the ozone water treatment plant reduces the risk of disease outbreaks at Coleman NFH (e.g., no IHNV outbreak for brood years 1999 or 2000 fall chinook juveniles) with a concomitant decrease in risk of transmitting disease(s) to naturally-produced juveniles in Battle Creek.

4.2 Livingston Stone National Fish Hatchery

Water Intake

The water supply for Livingston Stone NFH is provided by a pipe tapped directly into the penstocks of Shasta Dam. To ensure water reliability in the event one or more penstocks are not delivering water, the facility has the option to draw off of alternate penstocks[1]. Water is delivered from the penstocks to two gas equilibration columns atop an 18,000-gallon head tank. This head tank supplies the entire facility through a PVC manifold system. Total flow available to the facility is approximately 3,000 gpm.

The water delivery system at the Livingston Stone NFH is completely automated (computer controlled electronic valves), but manual overrides are built into the system. In the event of a power outage, an energy-dependent solenoid will trip thus allowing free flow (i.e., approximately 5,000 gpm) to the head tank. Although the head tank will overflow in this situation, the water

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[1] The facility is currently plumbed into two penstocks and in the future may be plumbed into four for improved reliability of water supply.

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supply to the rearing facility will be uninterrupted and fish production will not be at risk. Furthermore, since Shasta Dam is the primary electricity generating facility in Northern California, electrical grids at the facility are generally restored first, and power outages are expected to be short. A Service employee resides on-site to respond to emergencies occurring during non-business hours.

Water quality at Livingston Stone NFH is favorable for propagating winter chinook salmon (USDOI 1997). Suitable water temperature is achieved through operation of the Temperature Control Device at Shasta Dam. Turbidity is low because most suspended solids settle in Shasta Lake (reservoir) before the water is used at the Livingston Stone NFH. Disease concerns are minimal because it is unlikely that pathogens would be transmitted from Shasta Lake into Livingston Stone NFH for the following reasons: 1) Shasta Dam prevents upstream migration of anadromous salmonids into the hatchery water supply; and, 2) the water used at Livingston Stone NFH is taken from deep in Shasta Lake, where fish and pathogens are not generally present.

Water Discharge

Water used for fish production at Livingston Stone NFH is returned to Keswick Reservoir just below Shasta Dam. Water discharged from the Livingston Stone NFH is regulated by a NPDES permit issued by the California Regional WQCB (Attachment 4-3). The findings of this permit for Livingston Stone NFH are similar to those for Coleman NFH in that water discharge from the hatchery has been classified as "minor," and existing wastewater treatment technology "...is capable of consistently reducing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or ground water are adversely affected." Based on this assessment, the Service considers the risk of negative affects of water discharge on natural salmonid populations to be minimal (none to low). Monthly water supply and effluent monitoring includes parameters similar to those measured at Coleman NFH (see pg. 4-5).

4.3 Take of ESA-listed and non-listed salmonids resulting from hatchery water withdrawal.

Livingston Stone NFH

The Service anticipates no take of ESA-listed or non-listed salmonids through Livingston Stone NFH water intakes. Livingston Stone NFH obtains its water through penstocks located in the Shasta Dam. Because the dam prevents upstream migration of salmonids and water is withdrawn from deep in Shasta Lake, take of salmonids is not expected during hatchery water withdrawals.

Coleman NFH

Existing water diversions for Coleman NFH may result in take of juvenile ESA-listed and non-listed salmonids from Battle Creek. The primary intake for Coleman NFH is located in the tailrace of the Coleman powerhouse (an area inaccessible to anadromous salmonids), therefore, take of juvenile salmonids is not expected to occur at that location. However, water diversions at Intakes 2 and 3 may impinge or entrain juvenile salmonids because these intakes are either

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unscreened (Intake 2) or do not meet NMFS screening criteria (Intake 3). In the future all water entering the Coleman NFH will be screened with intake structures meeting NMFS' fail-safe screening criteria.

Take of juvenile salmonids at the Coleman NFH Intakes 2 and 3 may occur as either entrainment or impingement. The number of juvenile salmonids entrained or impinged at Intakes 2 and 3 is a function of: 1) the proportion of Battle Creek flow diverted into the hatchery; 2) the magnitude and timing of diversions at improperly screened intakes; and, 3) the magnitude and timing of salmonid emigrations past the Coleman NFH intake structures in Battle Creek. Based on the information presented below, we have estimated future take of juvenile salmonids resulting from Coleman water diversions using the assumptions shown (underlined).

1) *Proportion of Battle Creek flow diverted at Coleman NFH*

The proportion of Battle Creek flow diverted at Coleman NFH is a function of water requirements for fish propagation at Coleman NFH and Battle Creek flow. The amount of water diverted into Coleman NFH varies throughout the year, depending on the water demands for fish culture activities associated with various cycles of collecting, spawning, and rearing three stocks of anadromous salmonids (Figure 4-2). Total water use at the hatchery is highest from October through early-March (generally >100 cfs) when broodstock collection, spawning, egg incubation, and rearing all occur simultaneously. Lowest water use at Coleman NFH occurs in May (24 cfs) following the release of fall chinook salmon. Total diversion through the Coleman NFH intakes also includes 9.6 cfs appropriated for downstream irrigation after use in the hatchery and 13.13 cfs to be delivered to downstream water users without being used at the hatchery (Sverdrup and Tetra Tech/KCM, Inc. 1999). A detailed analysis of hatchery water requirements at Coleman NFH, broken down by species and rearing unit, are presented by Sverdrup and Tetra Tech/KCM, Inc. (1999).

Average monthly flow in Battle Creek ranges from a low of 255 cfs during September to a high of 727 cfs during January (Figure 4-2; USGS website: http://waterdata.usgs.gov/nwis-w/ca/ as summarized by Ward and Kier 1999). High baseline flows in Battle Creek create a year-round connection to the Sacramento River. However, elevated water temperature in the lower section of Battle Creek generally precludes salmonid movement into or out of the tributary during a portion of the summer (usually July). Winter flows in Battle Creek are influenced greatly by runoff from winter storm events, with high flow events generally occurring between January and March.

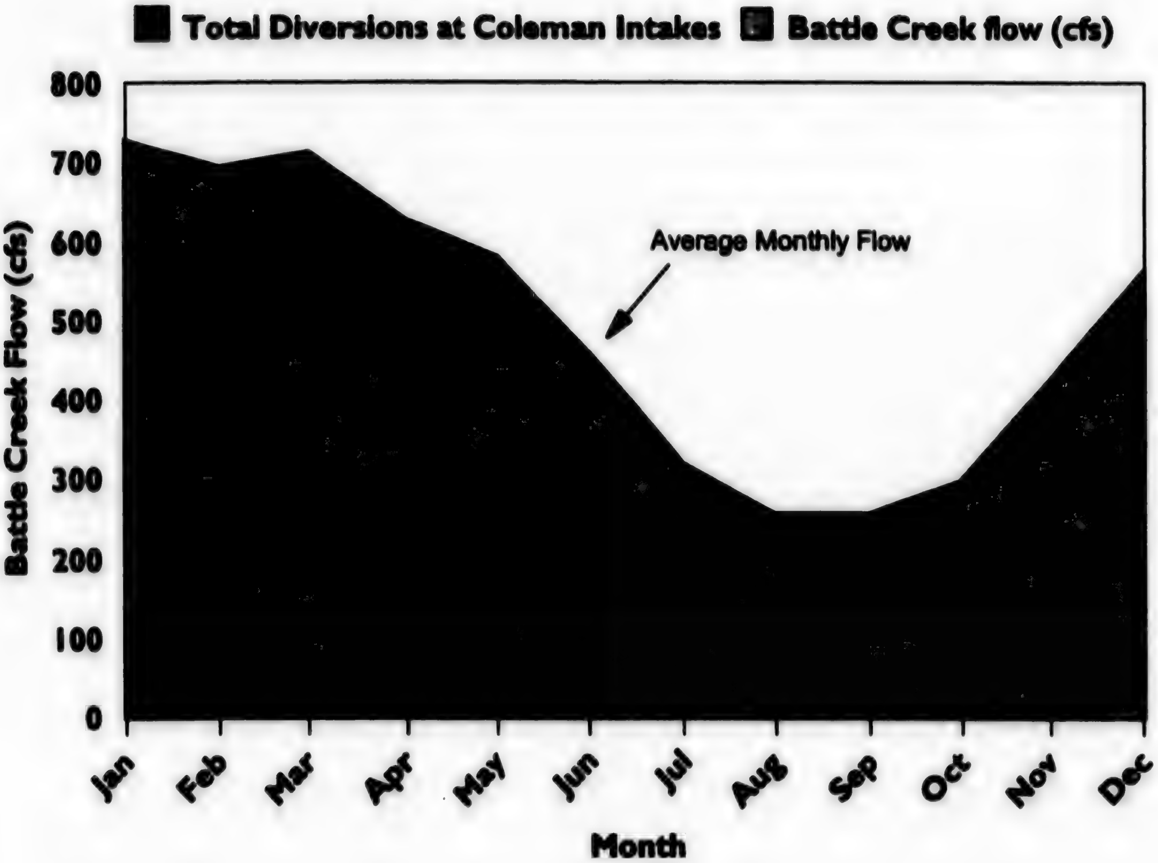

Figure 4-2. Annual hydrograph for Battle Creek and expected diversions at Coleman National Fish Hatchery intakes. Total diversions at Coleman National Fish Hatchery intakes includes approximately 23 cfs delivered to downstream water users. Monthly flow averages are based on data for Battle Creek from 1961 through 1996 (Ward and Kier 1999).

2) *The magnitude and timing of diversions at inadequately screened intakes*
Intake 1 is used as the primary source of water for Coleman NFH because it is located in an area isolated from anadromous salmonids. Coleman NFH water rights for Intake 1 are 39 cfs, with an additional 11 cfs available in a combined right with Intake 2. During normal operations, all of the 11 cfs available through the Intake 1 and 2 combined right is taken through Intake 1 yielding a total of 50 cfs available from Intake 1. Water rights at Intakes 2 and 3 are 22 cfs and 50 cfs, respectively.

From May through mid-July the hatchery's water requirements are low (< 50 cfs) and the hatchery's water supply can be fully supplied through Intake 1. When hatchery water demands increase above 50 cfs (mid-July to late-April), Intake 3 is used to supply additional water. Intake 3 is used preferentially to Intake 2 because Intake 3 is currently screened, and because current configuration of Intake 2 prevents simultaneous operation with Intake 1.

However, existing screens at Intake 3 do not meet NMFS current fail-safe criteria, thus they do not provide adequate protection to prevent entrainment or impingement of juvenile salmonids. To estimate future diversions through Intake 3, we have assumed that all water required to operate Coleman NFH in excess of that available through Intake 1 (50 cfs) will be collected at Intake 3.

Planned and unplanned diversions through Intakes 2 and 3 are also required for routine maintenance and emergency situations that interrupt water supply to Intake 1. The normal operating condition of the Coleman powerhouse involves discharge of flow from the Coleman forebay, through the penstocks and turbine, then discharge into the tailrace where the hatchery's Intake 1 is located. Occasionally, water is blocked from the Coleman powerhouse to perform routine maintenance of the PG&E canals and turbine. Maintenance activities of this sort are typically scheduled during May and June, to correspond with decreased water needs at Coleman NFH. However, unplanned events such as turbine trip or canal failure can also disrupt the water supply to Intake 1. When water is not available at Intake 1 because of maintenance or emergency situations, Intake 2 on Battle Creek automatically opens and diverts water to supply the hatchery. During recent years, Intake 2 has been used an average of 412 hours annually.

To estimate future diversions through Intake 2, we have assumed that Intake 2 will be used to divert water into Coleman NFH for 412 hours annually. We further assumed that Intake 2 will be used only when Intake 1 is inoperable; and that half of the hours of operation for Intake 2 (206 hours) will occur during May and June (as part of PG&E maintenance) and the remaining 206 hours will occur as randomly timed emergency events. To estimate take of juvenile salmonids at Intake 2 during emergency events we apportioned the hours equally from July through April.

3) *The magnitude and timing of juvenile salmonid emigrations past the Coleman NFH intake structures.*

The magnitude and timing of juvenile salmonid emigrations from upper Battle Creek have been monitored by the Service since late-1998. Monitoring data are currently available for only one complete broodyear, 1999. During 1999, the temporal distributions of juvenile emigrations for fall, late-fall, and spring chinook salmon and steelhead trout followed expected trends based on life history strategies characteristic of the various runs. For example:

- *fall chinook* typically dispersed downstream during the winter months, soon after emergence;
- *late-fall chinook* dispersal is more protracted, and extends from early spring (newly-emerged fry) to autumn (sub-yearlings);
- *spring chinook* disperse downstream primarily as smolts during high flow events in winter and spring months; and,
- *steelhead trout* dispersal occurs primarily during spring, as newly-emerged fry, and during autumn as smolts.

For winter chinook salmon, an insufficient number of juveniles were sampled for brood year 1999 (n = 1) to portray an adequate representation of migration timing. Therefore, we assumed that emigration timing of winter chinook salmon from upper Battle Creek would be similar to that observed in the upper Sacramento River (Martin et al. 2000):

- *winter chinook* juveniles emigrate as fry, primarily between the months of August and October.

To estimate future take of juvenile salmonids at Intakes 2 and 3, we have assumed that fall and late-fall chinook salmon and steelhead trout will exhibit emigration patterns similar to BY 1999. We assumed that winter chinook salmon would emigrate primarily as fry, from late-July through early-November as follows: 68% emigrate in September, 13.5% emigrate during August and October, and 2.5% emigrate during July and November.

Emigration estimates - The numbers of juvenile fall, late-fall, winter, and spring chinook salmon and steelhead trout emigrating past the Coleman NFH intakes in the near-term future (e.g., 5 years) can be estimated based on the following information: the number of adult salmonids expected to pass upstream of the Coleman barrier weir; the estimated fecundity of spawners; and, the expected survival of offspring to the time of emigration. Best available information on these factors are presented below. Based on these assumptions, we estimate the number of naturally produced salmonids emigrating from upper Battle Creek for brood years 2000-2005 as shown in Table 4-2.

Escapement past the barrier weir - We estimate total escapement of adults past the barrier weir at 1,500 fall chinook, 100 late-fall chinook, 100 winter chinook, 100 spring chinook, and 1,500 steelhead trout. Each of these figures has been liberally estimated based on data collected during monitoring efforts in recent years.

Fecundity of spawners - Fecundity of adults is estimated at 5,400 eggs per female for fall chinook, 4,500 for late-fall chinook, 3,500 for winter chinook, and 4,600 for steelhead trout and 4,200 for spring chinook. Fecundity of fall, late-fall, and winter chinook salmon and steelhead trout was estimated from hatchery records based on the most recent ten years of data (see Appendices 6A and 6B for eggs collected and numbers of female spawners). Fecundity estimates for spring chinook are from CDFG (1998).

Survival until downstream dispersal/emigration - Survival of naturally produced chinook salmon and steelhead trout eggs and juveniles in Battle Creek has not been determined. We estimated survival of naturally produced salmonids until to the time of emigration as follows: 25% survival from egg to fry; 59% survival from fry to pre-smolt/smolt. These estimates are based on survival estimates developed for winter chinook salmon and used in the winter chinook juvenile production estimate (Martin et al. 2000).

The primary life-stages of various runs of chinook salmon and steelhead trout at the time of downstream dispersal/emigration are assumed as follows: fall chinook emigrate primarily as fry; late-fall chinook emigrate ½ as fry and ½ as smolt; winter chinook emigrate primarily as fry; spring chinook emigrate primarily as smolt; and steelhead trout emigrate primarily as smolt. These migration timings are consistent with the predominant life-history strategies characteristic of the various salmonid stocks and data collected from the mainstem Sacramento River since 1995.

Table 4-2. Juvenile emigration estimates for naturally produced salmonids emigrating past the Coleman National Fish Hatchery water diversions in upper Battle Creek, 2000 to 2005. Survival estimates from egg to fry and from fry to smolt are presented in parentheses. See preceding text for table assumptions and value derivations.

	Adult Escapement	Number Females	Eggs / female	Production Number	Emigration Estimate	
					Fry (25% no. eggs)	Smolt (59% no. fry)
Fall Chinook	1,500	750	5,400	4,050,000	1,012,500	
Late-fall Chinook	100	50	4,500	225,000	28,125	16,594
Winter Chinook	100	50	3,500	175,000	43,750	
Spring Chinook	100	50	4,200	210,000		30,975
Steelhead Trout	1,500	750	4,600	3,450,000		508,875

4.4 Estimate of future take of juvenile salmonids at Coleman NFH water diversions

Based on best available information, we estimate total take of ESA-listed and non-listed salmonids at the Coleman NFH Intakes 2 and 3 at 19,556, 3,612, 7,013 and 933 for fall, late-fall, winter, and spring chinook salmon, respectively, and 7,641 for steelhead trout (Table 4-3). Take may occur as either impingement or entrainment. Juvenile take is expected to occur primarily as fry for fall and winter chinook, half fry and half smolt for late-fall chinook, and smolts for spring chinook and steelhead trout. Spreadsheets showing the derivation of these estimates are also included (Appendix 4A).

Our estimates of take resulting from water diversions at Coleman NFH do not account for salvage of fishes from the hatchery's water supply system. Previous attempts at salvaging entrained juveniles from the hatchery's canal or settling basin have been moderately successful at collecting entrained fishes by seining and electro-shocking. From May 24 to July 13, 2000, 782 salmon and 749 rainbow trout were collected following diversion into the hatchery's water supply system and returned to Battle Creek. Alternative and complementary salvage methods (e.g., fyke netting) are being explored in an attempt to collect more of the diverted juveniles.

As part of the Battle Creek restoration effort, Coleman NFH intakes are being re-designed to conform to all NMFS and CDFG guidelines for protection of salmonids. Selection of an intake design is underway, with significant input from the resource agencies and stakeholder groups. After a new intake design is chosen, NEPA proceedings and construction of new hatchery intake structures will require approximately two years to complete. Construction of a new water intake system at Coleman NFH will substantially decrease future impacts of water diversions at Coleman NFH.

Table 4-3. Estimated salmonid take levels resulting from Coleman National Fish Hatchery water diversions from Battle Creek. Numerical take estimates do not include fishes salvaged from the hatchery's water supply system (i.e., actual take will likely be less as some of these fish will be rescued during salvage operations).

	Species				
Type of Take	Fall Chinook	Late-fall Chinook	Winter Chinook	Spring Chinook	Steelhead Trout
Unintentional lethal take[a]	19,556	3,612	7,013	933	7,641
% of estimated outmigrants	1.9	7.3	16.0	2.2	1.5

[a] Juvenile take will occur as entrainment or impingement.

4.5 Effects of water diversions for Coleman NFH on salmonid habitats after proposed restoration

Since the early 1900's, Battle Creek flows have been diverted for irrigation, hatchery operations, and, primarily, hydroelectric development. Hatchery operations in Battle Creek began in 1895 with the construction of the Battle Creek Egg Taking Station operated by the U.S. Bureau of Fisheries. This facility was phased out of operation following the construction of Coleman NFH in 1942. Also located in the Battle Creek watershed is a State-run hatchery facility located at Darrah Springs on Baldwin Creek, and several private trout rearing facilities. Hydroelectric development in the Battle Creek watershed began in 1901 with the construction of the Volta Powerhouse by the Keswick Electric Power Company. As it exists today, the Battle Creek Hydroelectric Project is operated by PG&E and consists of eight small dams that divert a portion of the water from both the North and South forks of Battle Creek, as well as several tributaries and underground springs, through five powerhouses (see Ward and Kier 1999 for a more complete description). The majority of water diverted for hydropower projects is returned to Battle Creek through the Coleman powerhouse tailrace, located approximately 1.6 miles upstream of Coleman NFH.

Water diversions for hydroelectric power production have caused the largest impacts to habitats of anadromous salmonids in Battle Creek. Upstream of the Coleman Powerhouse, hydropower diversions have historically routed nearly all of the water from Battle Creek during the months from June until the rains began in the fall. Hanson et al. (1940) reported that "Battle Creek above the Coleman Powerhouse is not suitable for salmon because ditches remove practically all of the water from its bed and the little water remaining becomes very warm in the summer." Current minimum release requirements as stipulated in Federal Energy Regulatory Commission (FERC) licence #1121 are 3 cfs in the North Fork and 5 cfs in the South Fork Battle Creek.

Prior to Battle Creek restoration efforts, passage of anadromous fishes upstream of the Coleman barrier weir was intentionally blocked on a seasonal basis for various reasons including: 1) preventing disease-infected fish from entering the hatchery's water supply; 2) spatially separating fall and spring chinook to maintain stock integrity; 3) preventing fish from entering degraded habitat; 4) preventing fish from entering and spawning in areas of unscreened diversions. As part of the Battle Creek restoration efforts, an agreement was recently reached between resource agencies, stakeholders, and cooperators to open access and restore approximately 42 miles of anadromous fish habitat in Battle Creek that have primarily been affected by hydropower and hatchery operations. Several major changes have come about as a result of the Battle Creek restoration effort, including the construction of the ozone water treatment facility at Coleman NFH (alleviating concerns associated with passing disease-carrying adults upstream of the hatchery) and proposed alterations to the Battle Creek Hydroelectric Project involving increases in minimum flows, removal of some impediments to fish passage (i.e., dams), and improved fish passage around remaining structures.

While all aspects of Battle Creek restoration have not been determined, much of the visioning, research, and planning have been completed (e.g., TRPA 1998a through 1998d, Ward and Kier 1999, Sverdrup and Tetra Tech/KCM, Inc. 1999) and considerable progress has already been made towards finalizing restoration goals. For example, a draft EIS/EIR has been prepared with proposed

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modifications to the Battle Creek Hydroelectric Project (SWRCB 2000), and new minimum release requirements have already been agreed upon (MOU among NMFS, USFWS, CDFG, USBR, and PG&E dated June 10, 1999). The new minimum flow agreements, as renegotiated under the umbrella of the Battle Creek restoration project, include releasing 35 cfs and 40 cfs from the Eagle Canyon and Inskip dams respectively (MOU among NMFS, USFWS, CDFG, USBR, and PG&E dated June 10, 1999). These flows reflect an effort to balance power production needs with fish habitat requirements at various life-stages, and take into consideration water quality (e.g., temperature) and habitat availability. Stream flows reallocated under the Battle Creek restoration plan are designed to satisfy the life history requirements (e.g., upstream migration, spawning, egg incubation, rearing, and emigration) of priority species within restored stream reaches.

To assess possible effects of Coleman NFH water diversions on salmonid habitats after restoration of Battle Creek, we used the "preferred alternative" (Alternative 3) as a framework for reformed hydropower operations as described in the draft EIS/EIR (SWRCB 2000) (represented in Figure 4-3; see SWRCB 2000 for a complete description of proposed alternatives and current operations). This alternative calls for the removal/decommissioning of five dams and associated facilities on the North and South forks of Battle Creek (and some tributaries), as well as improved fish screening and increased minimum water releases.

Ward and Keir (1999) report recommended minimum flows between 45 and 112 cfs for the mainstem section of Battle Creek after full restoration (Table 4-4). The mainstem reach, which extends from the Coleman barrier weir upstream to the confluence of North and South Forks, encompasses an area affected by hydropower diversions and also includes the 1.2 to 1.6 miles of salmonid habitat below the Coleman Powerhouse which are affected by Coleman NFH water diversions. Although the section of Battle Creek that is affected by hatchery water withdrawals was not included in the original studies completed by Thomas R. Payne and Associates (TRPA 1998a through 1998d), a Biological Team developed by the BCWG extended flow recommendations to this section based on habitat similarities to the upstream reach that was investigated.

Coleman NFH's water supply is obtained from a combination of three intakes located 1.2 or 1.6 miles upstream of the hatchery (see section 4.1 for a complete description). Coleman NFH's primary source of water (Intake 1) is located in the tailrace of the Coleman powerhouse (Figure 4-3). Remaining water requirements are satisfied through Intake 3 (located in Battle Creek, 0.4 miles downstream of the Coleman tailrace), or in emergencies, from Intake 2 (located in Battle Creek, opposite of the Coleman tailrace).

Water flow in Battle Creek and water requirements for Coleman NFH vary depending on time of year and propagation efforts (Table 4-5; Sverdrup and Tetra Tech/KCM, Inc. 1999). Monthly water requirements for Coleman NFH range between and 34 and 119 cfs, including 9.6 cfs delivered to downstream users after use in hatchery propagation and approximately 13 cfs delivered to downstream users without being used at the hatchery. None of these conditions are expected to change after restoration efforts are completed. Water use at Coleman NFH is non-consumptive, so all water diverted for hatchery propagation efforts (except for the approximately 23 cfs that must be delivered to downstream users) is returned to Battle Creek at the hatchery site.

Coleman NFH water requirements and Battle Creek water flow vary substantially throughout the year. As a result, the risk of potential impacts to salmonid habitats within the hatchery-affected section of Battle Creek varies as well. Impacts to salmonid habitats caused by hatchery water withdrawals are likely greatest during late-summer and fall months when water requirements for Coleman NFH comprise the largest proportion of average monthly flows in Battle Creek (e.g., August through November; Table 4-5). Although water demands in December and January are higher, water flows in Battle Creek during those months are at higher as well, likely reducing the relative effects of hatchery water withdrawals (Table 4-5). To illustrate potential effects of hatchery water withdrawals from Battle Creek, we analyzed hatchery water requirements and minimum releases (after restoration) for August (Figure 4-3). We consider August to be the most critical month because: 1) monthly flows are typically low compared to other months; 2) upstream migration of adult salmonids is permitted through the Coleman barrier weir until about September 1; and, 3) winter chinook juveniles are recently-emerged and are potentially beginning their downstream migration at that time. Monthly flows are slightly lower in September and hatchery water requirements are higher than in August, but the hatchery's upstream ladder is closed and upstream migration of adults is no longer possible. Regardless, similar analyses for any month can be made using information from Table 4-5 and Figure 4-3.

Minimum releases from Eagle Canyon and Inskip Dams will be 35 cfs and 40 cfs, respectively (MOU among NMFS, USFWS, CDFG, USBR, and PG&E dated June 10, 1999). Based on these minimum releases, additional accretions (approximately 5 to 10 cfs) from small feeder streams (TRPA 1998a), and average monthly flow in Battle Creek, mainstem flows upstream of the Coleman Powerhouse tailrace would be approximately 80 cfs and hydropower diversions would be approximately 176 cfs during August (Figure 4-3). Coleman NFH water requirements are approximately 60 cfs in August, so 116 cfs would be returned to Battle Creek at the Coleman tailrace. Therefore, even during low flow months like August, flows in the hatchery affected stretch of Battle Creek will usually be higher than flows in the section of Battle Creek just upstream of the hatchery's intakes. If the minimum releases established to protect fish habitats in the mainstem section of Battle Creek are effective, impacts to fish habitat or passage associated with Coleman NFH water diversions should be minimal or non-existent since flows in this section of Battle Creek will be higher than the established minimum flows above the Coleman NFH water diversions (Figure 4-3). In fact, during August the majority of Battle Creek's natural flow (> 76%) will usually be present in the 1.6 miles affected by hatchery withdrawals.

While Battle Creek flows are sufficient to supply Coleman NFH's water requirements and to maintain recommended minimum flows during normal water conditions (see Table 4-5), this will not always be the case. Situations that would alter normal flow patterns fall into two major categories, equipment failures/emergencies (e.g., associated with hydropower diversions or facilities) and environmental conditions (primarily drought).

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Emergency Situations.
Occasionally, emergency situations arise with hydropower facilities causing an unplanned interruption in water flow from the Coleman tailrace. Under these circumstances, the Coleman tailrace empties, and no water is available for Intake 1 or returned to Battle Creek. Intake 2 automatically opens when Intake 1 is not available (Intake 3 may also be used), supplying Coleman NFH with water for hatchery operations. Water from the Coleman Canal begins filling the Coleman forebay. The Coleman forebay fills (this takes approximately 45 minutes to 1 hour) and eventually spills over and water is returned to Battle Creek.

Depending on time of year, Coleman NFH water requirements, and hydropower diversions, Coleman NFH water diversions may decrease flow in the 1.6 mile stretch of Battle Creek below the recommended minimum flow (see Table 4-4 for recommended minimum flows). Risks to habitat and natural salmonid populations from this type of emergency situation are thought to be minimal for several reasons. First, water within the penstocks and Coleman Powerhouse would still drain through the tailrace, so the Coleman tailrace would not drain immediately. Second, the Coleman forebay fills and overflows relatively quickly (usually less than 1 hour) and the location of the forebay ensures that overflow water returns to Battle Creek above the hatchery intakes. This means that water withdrawals from hatchery diversions should not decrease Battle Creek flows below the recommended levels for long (probably less than an hour). Second, because the water is moving and the minimum instream flow would remain unaffected upstream of the hatchery intakes, reductions in water flow in the hatchery affected section should not result in detrimental increases in water temperatures. And lastly, hatchery intakes cannot divert all of the water in Battle Creek, even at low flows, because of design constraints. Therefore, the hatchery affected section should not be de-watered, a migration corridor should remain open, and some habitat (though limited) would remain.

Drought
Drought conditions could also cause hatchery water withdrawals to lower water flows in the hatchery-affected section of Battle Creek below recommended minimum flows (see Table 4-4 for recommended minimum flows). Between 1961 and 1999, average daily flows in Battle Creek were less than total water requirements (Coleman NFH water requirements plus minimum recommended flows by month) 2.6% of the time (362 days out of 13,769 days on record) (USGS historic flow records). Most of the days where Battle Creek flow did not meet total water requirements in the 1.6 mile reach affected by hatchery diversions occurred in December (140 days) and January (86 days), when water requirements at Coleman NFH are greatest. Water temperature concerns (i.e., warming as result of decreased flows in this reach) should not pose a problem during those months. September (46 days) and October (62 days) were also revealed as potentially problematic months. However, similar to the emergency situation previously discussed, even during warmer months water is moving and the minimum instream flow would remain unaffected upstream of the hatchery intakes. Reductions in water flow associated with hatchery water withdrawals, therefore, should not result in detrimental increases in water temperatures. In addition, hatchery intakes cannot divert all of the water in Battle Creek, even at low flows, because of design constraints, so the hatchery affected section should not be de-watered, a migration corridor should remain open, and some habitat would remain.

We also examined the flow data for number of days and distribution of days where not only the recommended minimum flow values would not be met in the 1.6 mile reach affected by the hatchery diversion, but flows would also result in a weighted usable area (WUA)[2] of less than 95% (see Table 4-5 for 95% WUA values by month). Over the 38 years analyzed, flow in the hatchery-affected reach failed to meet the flow necessary for the 95% WUA approximately 0.8% of the time. Days with mean flows that were less than that necessary to maintain 95% WUA were limited to December (47 days), October (25 days), January (22 days) and February (10 days). As expected, time periods where effects were noted were largely consistent with known drought years (late-1970s, late-1980s, and early-1990s).

The results of these analyses demonstrate that during extreme drought conditions, water withdrawals from hatchery diversions could decrease Battle Creek flows in a 1.6 mile reach below the recommended minimum levels and, at times, below the 95% WUA level. Operational changes would likely need to be considered for these extreme conditions. For example, water from hatchery raceways could be re-used in the adult holding ponds from October through February in low water years. This operational change would reduce Coleman NFH water requirements by approximately 22 cfs. Based on the flow data from 1961 through 1999, this change would result in a failure to meet the 95% WUA only 0.3% of the time, equating to a 62% reduction of impact (i.e., 0.8% reduced to 0.3%). Additional operational scenarios will likely be developed to further minimize impacts.

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[2] Weighted usable area (WUA) is defined as the wetted area of a stream weighted by its suitability for use by species and lifestage (see Stalnaker et al. {1995} for a general discussion of WUA, see TRPA {1998a, 1998b, 1998c, 1998d} and Ward and Kier {1999} for specific information about generating estimated minimum flows for Battle Creek).

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Table 4-4. Flows providing maximum weighted usable area (WUA[a]) for different species and lifestages for the mainstem reach of Battle Creek (from the Coleman barrier weir to approximately 10 miles upstream). Flows are from the Battle Creek Working Group Technical Committee (reported in Ward and Keir {1999}) and are based primarily on four studies of Battle Creek completed by Thomas R. Payne and Associates (TRPA 1998a through 1998d). Blank cells indicate lifestage was not present or habitat was not used at this time.

	Recommended Monthly Minimum Flow (cfs)											
Species and habitat	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Steelhead spawning	136	136	136	136								136
Steelhead rearing	76	76	76	76	76	76	76	76	76	76	76	76
Fall chinook spawning										86	86	86
95% of total WUA	112	112	112	112	112	45	45	45	45	45	60	112

[a] Weighted usable area (WUA) is defined as the wetted area of a stream weighted by its suitability for use by species and lifestage (see Stalnaker et al. {1995} for a general discussion of WUA, see TRPA {1998a, 1998b, 1998c, 1998d} and Ward and Kier {1999} for specific information about generating these estimated minimum flows).

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Table 4-5. Average monthly discharge for Battle Creek (BC), recommended minimum flows after Battle Creek restoration, monthly water requirements for Coleman National Fish, and average flows in excess of minimum flows and Coleman NFH water requirements.

	Water Flow (cfs)											
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Average monthly flows for BC[a]	727	693	713	625	578	457	318	256	255	296	420	559
Recommended minimum flows[b]	137	137	137	107	80	80	80	80	80	80	80	137
Coleman NFH water requirements[c]	119	104	111	86	34	45	59	60	89	115	115	117
Average flow in excess of minimum recommended flows and Coleman NFH water requirements	471	452	465	432	464	332	179	116	86	101	225	305

a Average monthly flows for battle Creek were taken from Kier and Ward (1999) and are based on data from 1961 through 1996 (USGS gaging station 11376550).

b Minimum flows are based on agreed upon minimum releases from hydropower facilities after Battle Creek restoration (MOU among NMFS, USBR, USFWS, CDFG, and PG&E dated June 10, 1999) and estimated accretions (~5 cfs) from small tributaries. Implementation of the minimum releases is pending (anticipated start date late 2001 or early 2002).

c Coleman NFH water requirements include approximately 13 cfs delivered to downstream water users without being used at the hatchery.

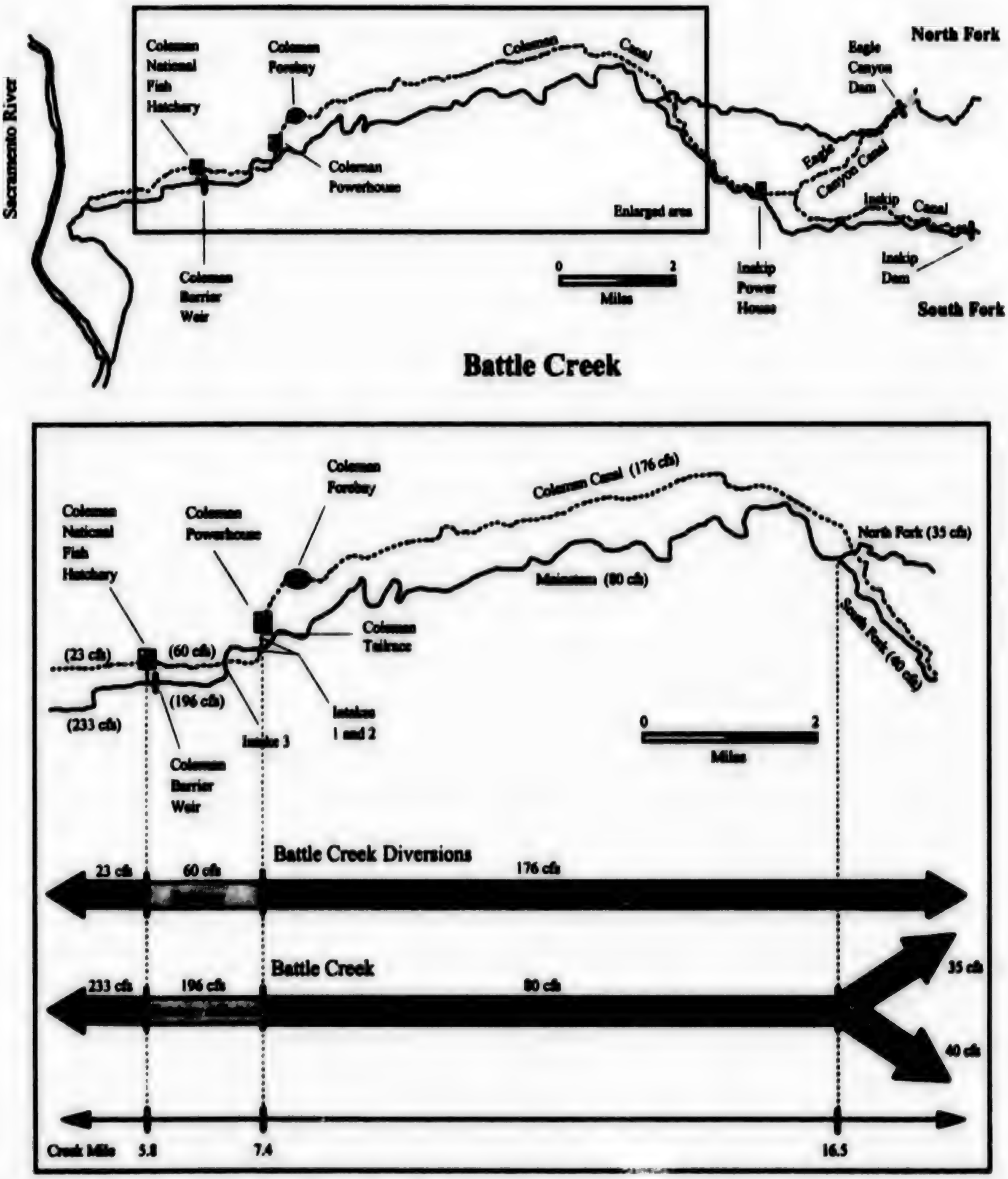

Figure 4-3. Map and schematic of water flow through sections of Battle Creek and Battle Creek diversions. Map reflects conditions after hydropower restoration of Battle Creek (see text for details). Water flows are based on agreed upon minimum releases (Memorandum of Understanding among USBR, NMFS, USFWS, CDFG, and PG&E dated June 10, 1999) and mean monthly flow for Battle Creek in August (Ward and Kier 1999). Flows are shown in cubic feet per second (cfs). Mainstem flow includes accretions from small tributaries (not shown) of approximately 5 cfs (range 5 - 10 cfs; TRPA 1998a).

FACILITIES

5.1 Coleman National Fish Hatchery

Property

Coleman NFH covers approximately 75 acres of land owned by the Service. An additional 63 acres of land are in perpetual easements for pipelines and access. Legal description of the lands, easements and water rights owned by the Government are as follows (from Luken et al. 1981):

- Two parcels of land in Section One, Township Twenty-nine North, Range Three West, Mount Diablo Base, and Meridian, and described in Land Purchase Control 149r-1079 dated September 25, 1942, as (a) 55.28 acres more or less by purchase, (b) 7.45 acres more or less by perpetual easement.
- Perpetual easement of the one parcel of land located in Section Two, Township Twenty-Nine North, Range Three West, containing 3.14 acres more or less, described in Land Purchase Contract 149r-1193.
- Perpetual easements in five parcels of land located in Section Thirty-one, Township Thirty North, Range Two West and one parcel in Section Two, Township Twenty-nine North, Range Three West, Mount Diablo Base and Meridian, totaling an aggregate of 93.4 acres, described in Land Purchase Contract 149r-1070.
  On September 5, 1957, a quitclaim deed was filed in Redding, California under Document No. 9318, Book O.R. 543, page 144, covering tracts 9R, Parcel A, 6R Parcel B, 5R-3 Parcel C an 8R Parcel D. There was a road right-of-way transferred to Shasta County. This easement is involved in the two items immediately above.
- Perpetual easement of a strip of land 200 feet in width containing an area of 11.8 acres of land in Section One, Township Twenty-nine North, Range Three West, Mount Diablo Base and Meridian, described in Land Purchase Contract 149r-1530.
- Twenty and thirteen hundredths (20.13) acres adjoining existing Service property on the west and located in Township 29 North, Range Three West, Mount Diablo Base and Meridian.

Physical Structures

Facilities at Coleman NFH include: the main hatchery building containing incubation chambers and tanks for early-rearing; administration building; cold storage/freezer building; garage and warehouse; storage buildings; spawning building; ozone water treatment plant and associated structures; and three residences. Additionally, the Service's California/Nevada Fish Health Center uses three buildings located on the hatchery grounds. Other structures for fish propagation include: twenty-eight 15-foot by 150-foot concrete raceways; thirty 8-foot by 80-foot concrete raceways; a pre-release rearing pond; a pollution abatement pond, and facilities for congregating, collecting, holding, and spawning broodstock (Figure 5-1).

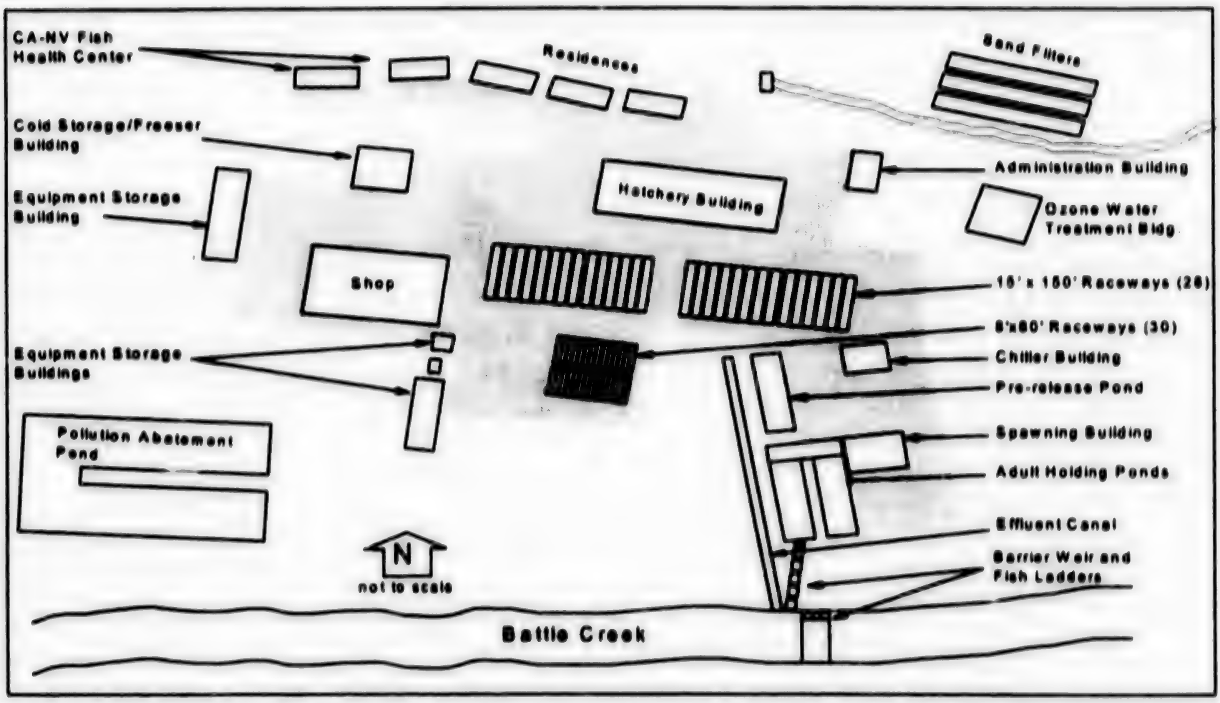

Figure 5-1. Physical layout of hatchery facilities at Coleman National Fish Hatchery.

Broodstock Collection Facilities

Broodstock congregation and collection facilities at Coleman NFH consist of a barrier weir with two associated fish ladders. Because Coleman NFH is located on Battle Creek, no transportation of brood stock is necessary. The Coleman NFH barrier weir and its associated fish ladders are located approximately six miles up from Battle Creek's confluence with the Sacramento River. The weir is permanent and extends across the full width of Battle Creek (approximately 90 feet). The primary purpose of the barrier weir is to congregate salmonids and divert them into the hatchery's adult collection and holding ponds. The weir's two fish ladders, both located on the north side of the creek, join in a common entrance. One ladder (upstream ladder) is connected to the weir and runs parallel to creek flow. When the upstream ladder is opened, adult salmon and steelhead have access above the barrier weir to upper Battle Creek. The other ladder (adult collection ladder) at the barrier weir is positioned perpendicular to Battle Creek and leads fish into the hatchery's adult holding ponds.

Adult Holding and Spawning Facilities

Adult holding and spawning facilities at Coleman NFH consist of four holding ponds of various configurations and a fully-mechanized facility for crowding, sorting, and spawning collected adults. Upon ascending the hatchery's adult collection ladder, salmonids are counted as they enter Pond 3, which measures 200 feet x 36 feet (volume = 30,600 ft^3). From Pond 3, collected fish are routed into the spawning building using mechanical weirs and crowders. The spawning building features a state-of-the-art spawning and sorting facility, and encloses two additional holding ponds (Ponds 4 and 5) measuring 81 feet-6 inches x 41 feet each (23,390 ft^3). During spawning operations, a hydraulic lift located in the spawning building raises fish into a carbon dioxide (CO_2) anaesthetization tank. Non-target fish can be returned immediately to Battle Creek during the initial sort process by shunting them down a tube emptying into Battle Creek above the hatchery's barrier weir. Pond 2 measures 188 feet x 12 feet (4,800 ft^3), and is used to hold adult steelhead after initial sorting.

Incubation and Indoor Rearing Facilities

Egg incubation facilities are located in the hatchery building. Incubation units consist of 178 sixteen-tray vertical fiberglass incubators (Heath Incubation Trays). The top tray of each incubation stack is not used to limit the exposure of incubating eggs to light and silt. Also located in the hatchery building are sixty-seven 16-foot x 3-foot 4-inch fiberglass tanks used for early-rearing of steelhead.

Outdoor Rearing Facilities

Outdoor rearing units include twenty-eight 15-foot x 150-foot raceways, thirty 8-foot x 80-foot raceways, and one 201-foot x 60-foot pre-release pond (Pond 1). The raceways are constructed of concrete. The 15-foot x 150-foot raceways are approximately 4 feet deep at the front end and 4 feet 9 inches deep at the lower end, containing approximately 5,600 ft^3. They are enclosed with a wire fence and covered by loosely-woven wire mesh to minimize predation by terrestrial and avian predators. The 8-foot x 80-foot raceways hold approximately 1,148 ft^3 of water. They are surrounded by wire fencing, but have no overhead protection against predators. The hatchery's pre-release rearing pond has concrete sides and a gravel bottom. Contrary to the name of this pond, the "pre-release" pond is currently used for extended rearing of steelhead trout, not to acclimate fish prior to release.

Fish Transportation Equipment

Coleman NFH uses two aerated distribution trucks with capacities of 1,200 gallons for transporting steelhead trout to the Sacramento River at Bend Bridge (RM 258) for release. Occasionally, fall and late-fall chinook are transported to off-site release locations as part of various research projects. However, production groups of fall and late-fall chinook are released directly into Battle Creek at the hatchery site using a helical fish pump and temporary piping.

Water Treatment Facilities

A water treatment facility capable of filtering 45,000 gallons per minute (gpm) and ozonating 30,000 gpm has been constructed at Coleman NFH to reduce sediment in the hatchery water supply and to alleviate recurrent disease problems. Operation of the ozone water treatment facility is expected to substantially lessen the occurrence of disease in hatchery production, which in turn minimizes the potential for disease transmission to naturally-produced stocks. Several documents thoroughly discuss the justification, selection, and construction of the ozone water treatment facility at Coleman NFH (USFWS 1986, USFWS 1987, USFWS 1989, USFWS 1997a, USFWS 1997b).

Operational Difficulties or Disasters That Led to Significant Fish Mortality
Battle Creek is the water source for Coleman NFH. Occasionally, the hatchery's water supply is laden with heavy silt loads associated with high-flow events in Battle Creek. In addition, Battle Creek has been identified as the source of about thirteen anadromous fish disease-causing organisms. Disease and high sediment loads have caused mortality of eggs, juveniles, and broodstock at Coleman NFH. The newly constructed water filtration and ozone disinfection systems at Coleman NFH will substantially reduce the risk of mortality associated with high sediment loads and disease-causing organisms in the hatchery water supply.

Back-up Systems and Risk Aversion Measures to Minimize the Likelihood for the Take of Fish Resulting from Equipment Failure, Water Loss, Flooding, Disease Transmission, or Other Events That Could Lead to Injury or Mortality
Low-water alarms and built-in redundancy in the hatchery's water delivery system are used to minimize the likelihood of fish loss due to failure of the hatchery's water supply. On-site residences for station staff help reduce response time in the event of an emergency. The alarm system also has a telephone "call-out" system to contact staff residing off-site. A state-of-the-art water filtration and ozone disinfection system (see Section 4) reduces the likelihood of fish loss due to heavy silt loads or disease transmission

Impacts of Facility Maintenance and On-site Construction on Listed Stocks or Critical Habitat
Current maintenance operations do not require disturbance of additional, previously undisturbed areas, and will not result in the loss of or degradation of critical habitat. Any habitat concerns associated with new construction projects will be addressed in Environmental Assessments, Environmental Impact Statements, Environmental Impact Reports, and other environmental compliance documents before projects begin. New projects are expected to comply with NEPA requirements to minimize impacts to critical habitat for listed species.

5.2 Livingston Stone National Fish Hatchery

Property
Construction of the Livingston Stone NFH, a substation of Coleman NFH, was completed in 1998. The Livingston Stone NFH is constructed on a 0.4 acre USBR-owned site approximately 0.5 miles below Shasta Dam. It is adjacent to the Sacramento River (west side), but outside the flood plain (Figure 5-2). Fish culture facilities at Livingston Stone NFH include twenty 12-foot diameter circular tanks for broodstock rearing, thirty 3-foot by 16-foot rectangular tanks for juvenile rearing, and two 20-foot diameter circular tanks for broodstock holding. A hatchery/office building contains twenty 15-tray stacks of Heath vertical incubators and sixty 30-inch diameter early-rearing tanks.

Broodstock Collection Facilities
Adult winter chinook salmon broodstock are collected from the Sacramento River at fish traps located at the Keswick Dam and the RBDD.

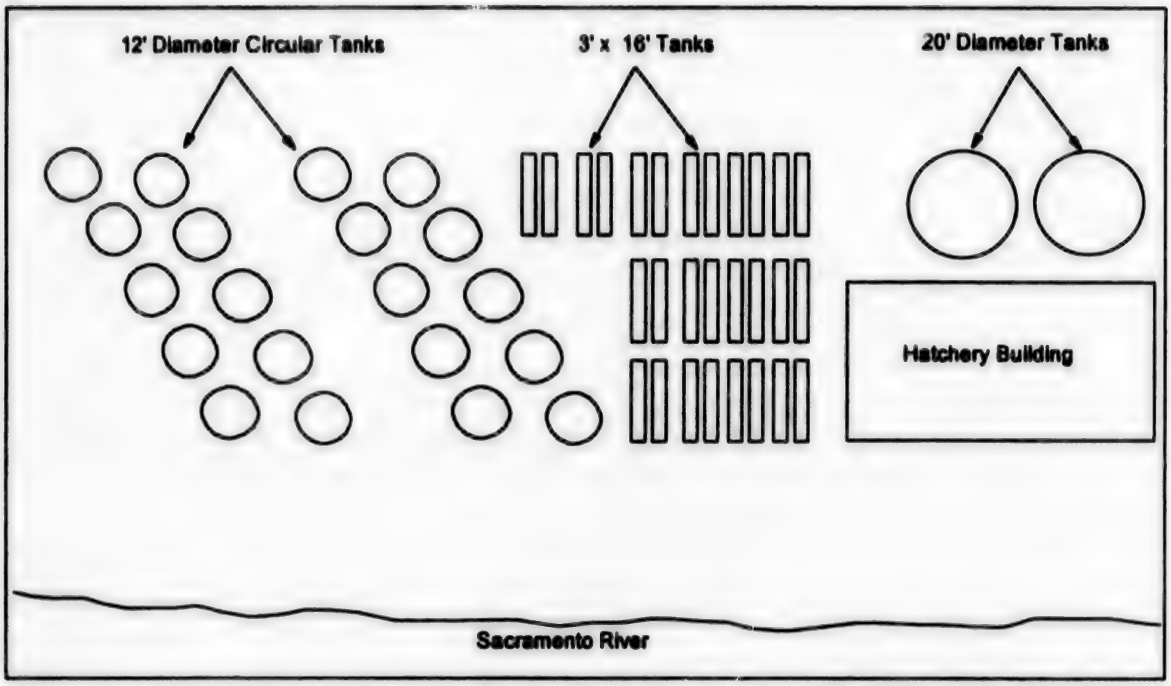

Figure 5-2. Physical layout of hatchery facilities at Livingston Stone National Fish Hatchery.

Keswick Dam Fish Trap - The Keswick Dam fish trap and associated structures are located in the center of the dam between the powerhouse and the spillway. Broodstock collection facilities consist of a twelve-step fish ladder, a brail-lift, and a 1,000-gallon fish-tank elevator.

Salmon and steelhead trout are attracted to the Keswick Dam fish ladder with a 340 cfs jet pump that supplies water to the trap and fish ladder. Additional flow for attracting fish is supplied through diffusers within the ladder floor. The fish ladder is approximately 170-feet long by 38-feet wide, and contains weirs which create pools. The top of the ladder leads to a fyke weir. After passing through the fyke weir, adult fish are contained in a large fiberglass brail enclosure. When the brail is raised, fish are directed into a 1,000-gallon elevator which transports them up the face of the dam to a fish distribution vehicle.

Several recent modifications to the Keswick Dam fish trap and associated structures have resulted in improved operation and maintenance of the structure: stop logs and an operating system for the fish ladder entrance were added for maintenance purposes; the original sweep/crowder has been completely removed and the trap brail and fish trap elevator have been modified for improved operation; and an escape channel was constructed which will permit trapped adults to volitionally exit the trap during high-flow events. These modifications are in accordance with CVPIA legislation calling for implementation of the Coleman National Fish Hatchery Station Development Plan (USFWS 1987). Previously, the

Keswick Dam fish trap limited operation to river flows below 16,000 cfs and necessitated that adults trapped during high-flow events be removed from the trap manually. With current improvements in place, the Keswick Dam fish trap was expected to be operable to river flows approaching 36,000 cfs; however, the actual season demonstrated operational flow may be less than 36,000 cfs, and additional modifications are underway. Adults captured during high-flow events can exit the trap on their own, through the new escape channel.

Red Bluff Diversion Dam Fish Trap - The RBDD is currently operated by the USBR; however, the fish ladder and trap at RBDD are maintained by the Service and operated by the CDFG. Winter chinook adults are occasionally obtained from the RBDD. The RBDD is generally used to collect winter chinook adults only when captures at Keswick Dam are insufficient to meet program goals. Collection of fish at the RBDD is authorized and conducted by the CDFG.

Winter chinook salmon are collected at RBDD in conjunction with passage monitoring conducted by the CDFG in the dam's east fish ladder. A fish trap located in the east fish ladder of the RBDD is operated from mid-May through Mid-September (while the gates are in) to enumerate and identify (by run) passing chinook salmon. When the trap is operating, fish ascending the RBDD ladder are diverted by a weir into a holding/examination area after jumping two false weirs. In the examination area, captured fish are anaesthetized with CO_2 and a determination of run (fall, late-fall, winter, or spring) is made based on phenotypic characteristics.

Fish Transportation Equipment
Adults collected in the fish traps at Keswick Dam or the RBDD are transported to Livingston Stone NFH in a fish distribution vehicle carrying an aerated 250-gallon insulated transport tank, or one of the two larger (1200 gallon) distribution vehicles from Coleman NFH. These larger vehicles are used for: 1) distribution of juvenile winter chinook salmon, 2) transfer of winter chinook juveniles to long-term, off-site rearing facilities (e.g., captive broodstock program); and, 3) transportation of adult chinook salmon to and from broodstock collection locations and back to the upper Sacramento River.

Broodstock Holding Facilities
Following transport to Livingston Stone NFH, fish are placed in quarantine tanks while awaiting the results of genetic analyses. The circular fiberglass quarantine tanks are 8 or 12 feet in diameter. Adult salmon genetically identified as winter chinook salmon are transferred into one of two 20-foot circular holding tanks. The holding tanks are connected to a carbon filter for detoxification of malachite green following prophylactic and therapeutic antifungal treatments of broodstock.

Spawning, Incubation, and Rearing Facilities
The Livingston Stone NFH spawning and rearing building is a 2,700-square foot insulated steel building containing egg and fry incubation units, sixty 30-inch diameter circular tanks for early-

rearing, a 100 square-foot walk-in freezer, and an office. Thirty-two 3-foot x 16-foot rectangular tanks are used for early-rearing and twenty 12-foot diameter circular tanks are used for captive broodstock holding and rearing.

Back-up Systems and Risk Aversion Measures That Will Be Applied to Minimize the Likelihood for the Take of Listed Natural Fish That May Result from Equipment Failure, Water Loss, Flooding, Disease Transmission, or Other Events That Could Lead to Injury or Mortality
The water delivery system for Livingston Stone NFH is equipped with a low-water alarm. In the event of an emergency (e.g, power outage), the penstock supplying Livingston Stone NFH defaults to open. This causes an overflow but ensures continued water supply to the juvenile salmon. On-station housing increases the likelihood of immediate response to emergencies during non-business hours.

Impacts of Facility Maintenance and On-site Construction on Listed Stocks or Critical Habitat
Livingston NFH is situated upstream of Keswick Dam and all critical habitat; therefore, current maintenance operations do not affect critical habitat for salmonids. Any possible habitat concerns associated with new construction projects will be addressed in Environmental Assessments, Environmental Impact Statements, Environmental Impact Reports, and other assessment documents before projects begin; however, new projects are not expected to affect critical habitat of salmonids since this hatchery is located upstream of Keswick Dam and designated critical habitat

BROODSTOCK ORIGIN AND IDENTITY

6.1 Source

Fall Chinook Salmon

Fall chinook salmon broodstock will be selected from natural- and hatchery-origin adults collected at the hatchery on Battle Creek.

Late-fall Chinook Salmon

Late-fall chinook salmon broodstock will be selected from hatchery-origin adults returning to the hatchery on Battle Creek and natural-origin adults captured at the Keswick Dam fish trap.

Winter Chinook Salmon

Broodstock for the winter chinook supplementation program are obtained from the mainstem Sacramento River. Adults are collected primarily at the Keswick Dam fish trap, supplemented, when necessary, with collections at the RBDD fish trap. Natural-origin adults are used primarily as broodstock. A maximum of 10% hatchery-origin adults are utilized as broodstock when necessary to meet production objectives.

Steelhead Trout

Steelhead trout broodstock will be selected from adults collected at Coleman NFH on Battle Creek. Both hatchery- and natural-origin steelhead trout will be spawned at Coleman NFH.

6.2 History

Fall Chinook Salmon

Prior to construction of the Coleman NFH in 1942 another propagation facility, the Battle Creek Egg Taking Station, was operated on Battle Creek by the State of California since 1895. The source of fall chinook broodstock for the Battle Creek Egg Taking Station was the indigenous population of fall chinook salmon in Battle Creek. A series of racks (weirs) were seasonally erected in Battle Creek to block the migration of adult fall chinook salmon and broodstock were obtained by seining them from congregations blocked behind the racks. Occasionally, broodstock collections for the Battle Creek Egg Taking Station were supplemented by seining adults from the mainstem Sacramento River.

Following construction of the Coleman NFH, adult fall chinook salmon were collected using seasonally installed weirs in Battle Creek and the mainstem Sacramento River and the Keswick Dam fish trap. The weir at Balls Ferry was abandoned after 1945 because of recurrent washouts during high flow events. In 1950, a barrier weir was constructed on Battle Creek at the site of Coleman NFH and the seasonally installed weirs were subsequently phased out of operation. From 1950 through1986, fall chinook broodstock were collected utilizing the barrier weir in

Battle Creek and from the Sacramento River at the Keswick Dam fish trap. Since 1987, fall chinook broodstock have been obtained exclusively at the hatchery on Battle Creek. A complete compilation of historical sources for fall chinook broodstock is in Appendix 6A.

Late-fall Chinook Salmon
Founding broodstock for Coleman NFH late-fall chinook salmon were collected at the Keswick Dam fish trap in the early 1950's. However, hatchery records do not formally recognize late-fall chinook salmon as a completely separate run from fall chinook salmon until 1973. Prior to 1973, fall and late-fall chinook salmon were partially-segregated at Coleman NFH. At that time, separation between the "early-arriving fall run" and "late-arriving fall run" was based on location of adult collection and spawn timing. The "early segment of the fall run" was typically spawned beginning about October 1 from adults collected at Battle Creek. The "late segment of the fall run" were spawned after about November 15, from adults collected at the Keswick Dam fish trap. Spawning of the combined-run extended from early-October through late-March (see Appendix 8A).

Since 1973, late-fall chinook have been formally recognized as distinct from fall chinook salmon at Coleman NFH. From 1973 to 1982, late-fall chinook broodstock were obtained exclusively from the Keswick Dam fish trap. Beginning in 1982, returns of hatchery-origin late-fall adults to Battle Creek were also used as hatchery broodstock. From 1982 through 1996, collections of late-fall chinook salmon broodstock at the Keswick Dam fish trap were phased-out in favor of volitional returns to the hatchery on Battle Creek. Since 1997, hatchery-origin returns to Battle Creek have been used exclusively as late-fall chinook broodstock at Coleman NFH.

Winter Chinook Salmon
The current winter chinook propagation program was initiated at Coleman NFH in 1988. The winter chinook propagation program was re-located to Livingston Stone NFH in 1997 to improve integration with natural-origin winter chinook salmon in the upper Sacramento River. The winter chinook supplementation program obtains broodstock from the mainstem Sacramento River. Adults are collected primarily at the Keswick fish trap, supplemented, when necessary, with collections at the RBDD fish trap. Broodstock are primarily natural-origin. A maximum of 10% hatchery-origin adults are used as broodstock when necessary to meet production objectives. All aspects of the winter chinook salmon propagation previously conducted at Coleman NFH and now executed at the Livingston NFH are covered under an ESA Section 10 permit (# 1,027).

Steelhead Trout
Steelhead trout have been propagated at Coleman NFH since 1947. Founding broodstock (19 females/unknown males) were collected from the Sacramento River at the Keswick fish trap. From this initial propagation effort, more than 11,000 fingerlings were released and an additional 500 juveniles were retained as station broodstock. From 1949 through 1951, only captively-reared steelhead trout broodstock were spawned at Coleman NFH. The captive broodstock program for steelhead trout was terminated in 1952. From 1952 through 1986 steelhead trout

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were collected from both Battle Creek and the Sacramento River at the Keswick fish trap. Beginning in 1987, steelhead trout broodstock have been collected only at Battle Creek, using both hatchery- and natural-origin adults. A compilation of historical sources for steelhead and rainbow trout broodstock is presented in Appendix 6B. In future years, the Service will continue to collect steelhead trout broodstock from Battle Creek, incorporating both hatchery- and natural-origin fish.

6.3 Transfers from other hatcheries

Fall Chinook Salmon

Current policy at Coleman NFH prohibits receipt of egg transfers from other hatcheries. Hatchery records indicate, however, that eggs have previously been received at Coleman NFH from various locations in California and, in one instance, from out of state (see Appendix 6A). Most transfers of fall chinook eggs to Coleman NFH originated from state-operated hatcheries in the Central Valley. Imports of eyed eggs from Nimbus Hatchery on the American River occurred in 1958, 60, 61, 64, 65, 68, 72, and 74-79. Eyed eggs were transferred to Coleman NFH from the Feather River Fish Hatchery in 1974, 77, and 83. A few transfers of fall chinook eggs to Coleman NFH originated from outside of the Central Valley Basin, including eggs received from: Klamath River (1958); Fall Creek Hatchery (1960); and Mad River Hatchery (1970). In all years, collection of eggs from locally-obtained broodstock far exceeded the number of eggs transferred into the Coleman NFH. There have been no transfers of fall chinook salmon into Coleman NFH since 1983.

Late-fall Chinook Salmon

Late-fall chinook salmon are propagated only at Coleman NFH. There have been no transfers of late-fall chinook salmon into Coleman NFH from other hatcheries.

Winter Chinook Salmon

Winter chinook salmon have been propagated only at Coleman NFH (formerly) and Livingston Stone NFH (currently). There have been no transfers of winter chinook salmon into Coleman or Livingston Stone NFH's.

Steelhead Trout

Steelhead eggs have been transferred to Coleman NFH from various other locations, mostly from State-operated hatcheries in the Central Valley. Eyed eggs from Nimbus Hatchery on the American River were received in 1972, 75, 76, 77, and 84. A shipment of eyed eggs was also received from the Feather River Hatchery in 1989. The only transfer of steelhead eggs originating from outside the Central Valley Basin was received from the Mad River Fish Hatchery in 1978.

In addition to steelhead trout, several strains of non-migratory rainbow trout were propagated at Coleman NFH from 1950-1978. The goal of the "catchable trout" program at Coleman NFH was to supply non-anadromous rainbow trout for put-and-take fisheries in Shasta and Whiskeytown lakes and at local military bases. At Coleman NFH, anadromous and non-anadromous strains of

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rainbow trout were generally spawned separately. However, during the early 1960's nearly 250,000 Gerrard strain rainbow trout (Kamloops) were apparently released into anadromous waters of the Sacramento River. The extent of hybridization between these fish and hatchery- and natural-origin steelhead trout cannot be determined. A complete compilation of historical sources for steelhead broodstock at Coleman NFH is located in Appendix 6B.

6.4 Annual size

Fall Chinook Salmon
The numbers of fall chinook salmon spawned at the Battle Creek Egg Taking Station and Coleman NFH since 1910 are shown in Appendix 6A. Broodstock sizes range from a low of 826 in 1978 to over 11,700 in 1988. Current and projected future broodstock requirements for Coleman NFH are approximately 2,500 pairs of mixed natural- and hatchery-origin fall chinook salmon.

Late-fall Chinook Salmon
Hatchery production of late-fall chinook peaked in 1981 when nearly 1,500 (814 females / 684 males) adults were spawned at Coleman NFH producing over 3.5 million eggs. Following that year, production of late-fall chinook at Coleman NFH decreased. A production target of one million late-fall chinook was eventually adopted to balance competing needs for space and water with the steelhead trout propagation program. To achieve the current production target of one million late-fall chinook smolts, the annual broodstock requirement is approximately 270 spawning pairs.

Winter Chinook Salmon
The collection target for winter chinook salmon broodstock is 15% of the estimated run-size, with a maximum of 120 naturally-produced adults. Monthly collection targets are determined based on the percentages of historic run timing past the RBDD. A minimum of 20 winter chinook adults will be targeted for capture during any year regardless of run size (e.g., run size <133).

Steelhead Trout
The number of steelhead spawned annually at Coleman NFH has varied considerably, depending on the availability of adults and fluctuating production goals. Maximum production occurred in 1965 when nearly 1,500 female steelhead trout were spawned at Coleman NFH. Following that year, production of steelhead trout decreased at Coleman NFH. A production target of 600,000 smolts was eventually adopted to balance the competing needs for rearing space and water with the late-fall chinook salmon propagation program. The number of broodstock necessary to achieve the current production target of 600,00 steelhead smolts is approximately 200 spawning pairs annually.

6.5 Past and proposed level of natural fish in broodstock

Fall Chinook Salmon

Past Levels of Natural Fall Chinook Broodstock:

From the early-1940's through the early-1970's the Keswick Dam fish trap regularly contributed greater than half, and as much as 75% (1957), of the fall chinook broodstock spawned at Coleman NFH. Collections of fall chinook broodstock from the Keswick Dam fish trap on the Sacramento River were considered to be primarily of natural-origin. During the drought years of 1976 and 1977, all fall chinook broodstock for Coleman NFH were collected at the RBDD (RM 243). During those years, natural-origin fish likely contributed a large proportion of collected adults.

The practice of obtaining fall chinook broodstock from the Sacramento River was phased out beginning in 1977. During 1985 and 1986, only one or two percent of the total fall chinook spawned at Coleman NFH were captured at the Keswick fish trap. Fall chinook broodstock have not been collected from the mainstem Sacramento River since 1986.

Future Levels of Natural Fall Chinook as Broodstock:

All fall chinook broodstock used at Coleman NFH since 1987 have been collected from Battle Creek. Fall chinook salmon in Battle Creek are comprised of adults originating from both hatchery and natural production. Actual physical counts of natural-origin fall chinook incorporated as hatchery broodstock are not available because hatchery- and natural-origin fall chinook are not distinguishable based on appearance. However, marking data suggest considerable numbers of natural-origin fall chinook enter the hatchery's collection ponds and are incorporated as broodstock at Coleman NFH. Juvenile fall chinook salmon at Coleman NFH have been marked at a rate of 8% since 1995. Hatchery returns of marked adults during 1998 and 1999 were 4.8% and 6.3%, respectively. Dilution of marked (hatchery-origin) fall chinook salmon likely results from collection of unmarked (naturally-produced) adults entering the hatchery ponds. We estimate, by standardizing the return of marked fish at 8%, that approximately 3,725 and 2,060 naturally-produced fall chinook salmon entered Coleman NFH during 1998 and 1999, respectively. These estimates of naturally-produced fall chinook collected at Coleman NFH equate to 8.4% (1998) and 7.6% (1999) of the total adults collected at the hatchery and are in close agreement with previous estimates of approximately 10% natural-origin fall chinook adults in Battle Creek. To better estimate natural return of fall chinook salmon to Battle Creek, we conducted a carcass survey during 2000. The purpose of the survey was to estimate the proportion of marked (hatchery) versus unmarked (natural) fall chinook salmon returning to Battle Creek during adult migration and spawning.

While researchers agree that incorporating natural adults into hatchery stocks helps minimize divergence, data on appropriate rate (or amount) of incorporation are lacking. The Service considers the approximate 10% incorporation of naturals as adequate (in the absence of concrete data) to prevent divergence between the hatchery and natural populations.

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Late-fall Chinook Salmon

Past Levels of Natural Late-fall Chinook as Broodstock:
From the early 1950's through 1982 late-fall chinook broodstock were obtained from the Sacramento River at the Keswick fish trap. Late-fall adults collected at the Keswick fish trap are considered to be natural-origin. Beginning in 1982, returns of hatchery-origin late-fall adults to Battle Creek were used as hatchery broodstock. From 1982 through 1989, collections of late-fall chinook salmon broodstock at the Keswick Dam fish trap were phased-out in favor of volitional returns to the hatchery on Battle Creek. Since 1997, only hatchery-origin late-fall chinook collected at the hatchery on Battle Creek have been spawned at Coleman NFH (Table 6-1).

Table 6-1. Number of late-fall chinook salmon collected from Battle Creek and the Sacramento River at the Keswick Dam fish trap, for years 1988 - 2000.

Year	Number of late-fall chinook collected		Percent collected at Keswick
	Battle Creek	Keswick Fish Trap	
1988	53	404	88
1989	65	817	93
1990	92	100	52
1991	161	118	42
1992	399	388	49
1993	528	375	42
1994	598	154	20
1995	492	224	31
1996	1,337	48	3
1997	4,578	0	0
1998	3,069	0	0
1999	7,075	0	0
2000	4,083	0	0

Future Levels of Natural Late-fall Chinook as Broodstock:
Beginning in 2002, the Service will re-initiate periodic collections of natural-origin late-fall chinook salmon from the Keswick Dam fish trap. Naturally produced late-fall chinook salmon will be re-incorporated as hatchery broodstock to reduce the likelihood of deleterious genetic impacts that may occur to isolated hatchery stocks (i.e., domestication and genetic divergence). Collection of natural-origin late-fall chinook salmon for broodstock will occur across the range of run timing to help ensure a representative sample of the natural population is incorporated as broodstock.

During 2002, 2003, and 2004 natural-origin late-fall chinook salmon will be collected from the upper Sacramento River in numbers equal to approximately 25% (n = 135) of the annual spawning target at Coleman NFH (n = 540). For the following three years (2005 through 2007), hatchery broodstock will consist exclusively of marked (hatchery-origin) returns to Battle Creek. For 2008 through 2010, 25% of the hatchery's late-fall chinook salmon broodstock will be collected again from the upper Sacramento River (Table 6-2). This cycle of infusing 25% natural-origin broodstock every-other-generation (assuming age-3 maturity) will benefit the hatchery stock by increasing genetic variability and decreasing domestication effects. The potential for genetic divergence between hatchery and natural stocks will also be reduced.

While researchers agree that incorporating natural broodstock is necessary to decrease divergence between hatchery and natural populations (e.g., Reisenbichler and McIntyre 1986, Lichatowich and McIntyre 1987, Cuenco et al. 1993, NMFS 2000), efforts to quantify the amount necessary to prevent large amounts of divergence are just beginning (e.g., Harada et al. 1998). This strategy of incorporating approximately 25% naturals as broodstock is a 'best guess'

Table 6-2. Proposed strategy for incorporating naturally-produced late-fall chinook salmon collected from Keswick Dam fish trap as broodstock for Coleman National Fish Hatchery. Example is for a total hatchery spawning requirement of 540 adults annually (half male and half female).

Brood year	Natural-origin (Keswick)	Hatchery-origin (Battle Creek)	Total Spawners	
[redacted]	[redacted]	[redacted]	[redacted]	First Generation
2003	135	405	540	
2004	135	405	540	
[redacted]	[redacted]	[redacted]	[redacted]	Second Generation
2006	0	540	540	
2007	0	540	540	
[redacted]	[redacted]	[redacted]	[redacted]	Third Generation
2009	135	405	540	
2010	135	405	540	
[redacted]	[redacted]	[redacted]	[redacted]	
2012	0	540	540	
2013	0	540	540	

to balance the need to incorporate natural adults as broodstock with the risk of removing a proportion of the natural spawning run. Strays from the hatchery stock should be sufficient to replace the natural spawners taken as broodstock for Coleman NFH (see Section 7.10 for a more complete discussion). A periodic rate of 25% incorporation for natural late-fall chinook salmon, as opposed to an annual 10% incorporation rate as with fall chinook and steelhead trout, was also chosen to balance the need to incorporate natural adults as broodstock with the risk and expense associated with transporting these fish to Coleman NFH.

Winter Chinook Salmon

Natural-origin broodstock salmon comprise the majority of past and present broodstock for the winter chinook supplementation program. Incorporation of hatchery-origin broodstock is limited to 10% of the number of adults collected for the program.

Steelhead Trout

Past Levels of Natural Steelhead Trout as Broodstock:

Natural-origin steelhead trout have been regularly incorporated as broodstock at Coleman NFH. From the late-1940's through the mid-1980's, substantial numbers of natural-origin adults from Keswick Dam were collected and spawned at Coleman NFH (see Appendix 6B). Steelhead trout collected at the Keswick fish trap are mostly of natural-origin. Since 1986, collection of steelhead trout broodstock has occurred exclusively at Battle Creek. Steelhead trout in Battle Creek are considered to be of mixed-origin, representing the progeny of artificial spawning at Coleman NFH and natural production in Battle Creek. However, until recently, hatchery- and natural-origin steelhead trout in Battle Creek were not distinguishable. Consequently, the rate that natural-origin steelhead trout have been incorporated as hatchery broodstock cannot be determined. A 100% marking program for steelhead trout was instituted at Coleman NFH for brood year 1998. By 2002, all adult hatchery-origin steelhead trout in Battle Creek will be identifiable by an adipose fin-clip.

Future Levels of Natural Steelhead Trout as Broodstock:

The Service will continue to collect and spawn both hatchery- and natural-origin steelhead trout at Coleman NFH[1]. Natural-origin (unmarked) steelhead trout collected at Coleman NFH will be used as broodstock at a rate of 10% (n = 40) of the annual spawning target (n = 400). The number of marked and unmarked steelhead collected, spawned, and passed above the barrier weir at Coleman NFH will continue to be closely monitored. Collection of natural-origin steelhead trout for broodstock will occur across the range of run timing to help ensure a representative sample of the natural steelhead population is incorporated as broodstock.

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[1] For brood year 2001 all unmarked steelhead trout will be released above the barrier weir in Battle Creek. This one-year hiatus of spawning natural-origin steelhead trout at Coleman NFH is necessary to allow time for ESA section 10 permitting.

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While researchers agree that incorporating natural broodstock is necessary to decrease divergence between hatchery and natural populations (e.g., Reisenbichler and McIntyre 1986, Lichatowich and McIntyre 1987, Cuenco et al. 1993, NMFS 2000), efforts to quantify the amount necessary to prevent large amounts of divergence are just beginning (e.g., Harada et al. 1998). This strategy of incorporating approximately 10% naturals as broodstock is a 'best guess' to balance the need to incorporate natural adults as broodstock with the risk of removing a proportion of the natural spawning run.

6.6 Genetic or ecological differences

Fall Chinook Salmon

This stock is considered to be genetically similar to the remaining endemic stock of fall chinook salmon Battle Creek and the upper Sacramento River. This similarity results from: 1) a long history of fall chinook hatchery propagation in Battle Creek; 2) indigenous fall chinook salmon were used as founding broodstock; and, 3) continuous and substantial genetic exchange between natural- and Coleman NFH-propagated stocks. Considered together, naturally-produced fall chinook salmon and fall chinook propagated at Coleman NFH comprise one homogeneous population containing mixed ancestry of hatchery and natural lineage.

Late-fall Chinook Salmon

Coleman NFH late-fall chinook salmon are considered to be genetically similar to the remaining endemic stock of late-fall chinook salmon in the upper Sacramento River. This similarity results from: 1) a long history of late-fall chinook hatchery propagation at Coleman NFH; 2) indigenous late-fall chinook salmon from the Sacramento River were used as founding broodstock; and, 3) substantial genetic exchange between natural- and Coleman NFH-propagated stocks.

Winter Chinook Salmon

The winter chinook salmon supplementation program at Livingston Stone NFH is designed to avoid creating a hatchery run. Indigenous winter chinook salmon are the only source of hatchery broodstock. Naturally spawning winter chinook are collected primarily at the Keswick Dam fish trap, the migration terminus of the upper Sacramento River. Selection of winter chinook broodstock is accomplished by screening all collected adults using several diagnostic criteria developed to reliably discriminate winter chinook salmon. To be selected as hatchery broodstock, adult salmon must satisfy both phenotypic criteria (run/spawn timing, collection location, and physical appearance) and genetic criteria (based on seven to ten loci that provide effective discrimination of winter chinook see Appendix 6C for more information). In combination, the genetic and phenotypic criteria enable accurate and precise identification of winter chinook salmon for use in the winter chinook salmon artificial propagation program at Livingston Stone NFH.

Steelhead Trout

Steelhead trout broodstock at Coleman NFH are genetically similar to naturally producing steelhead trout in Battle Creek and the upper Sacramento River. Founding broodstock for Coleman NFH steelhead trout were collected from the indigenous population in the upper

Sacramento River. Coleman NFH steelhead trout are included in the Central Valley steelhead trout ESU. In the 1996 status review of West Coast steelhead, the NMFS identified steelhead trout from Coleman NFH and natural-origin steelhead trout from Mill and Deer Creeks to form a small, coherent, and distinctly identifiable genetic grouping when compared to other steelhead populations in California and the West Coast (NMFS 1996). An ongoing Service investigation will use nuclear microsatellite analysis to further examine genetic similarities between natural-origin steelhead in Mill, Deer, and Clear Creeks, the mainstem upper Sacramento River, and hatchery-origin steelhead from Coleman NFH. Results of this analysis will be used to help determine the potential utility of Coleman NFH steelhead trout for recovery efforts in other areas of the upper Sacramento River system.

6.7 Reasons for choosing broodstock

All broodstocks for artificial propagation programs at Coleman and Livingston Stone NFH's are (or have been) chosen from local hatchery and natural populations in Battle Creek and the upper Sacramento River. Hatchery stocks were founded from local natural populations, and incorporating both hatchery and natural adults as broodstock is intended to reduce risks of negative impacts to natural populations from hatchery propagation efforts. See below for a more complete description of broodstock selection by stock.

Fall Chinook Salmon

Founding broodstock for fall chinook salmon at Coleman NFH were obtained from the Sacramento River and Battle Creek. Adult fall chinook broodstock were regularly collected at the Sacramento River until 1986. Since 1987, fall chinook broodstock have been collected only at the hatchery on Battle Creek. Fall chinook salmon in Battle Creek are comprised of both hatchery- and natural-origin fish.

Fall chinook broodstock at Coleman NFH are randomly selected from the total number of ripe adults >650 mm FL collected at the hatchery on Battle Creek. Jacks (males < 650 mm FL; approximately age-2) are incorporated at a rate of approximately 5% of the number spawned.

Late-fall Chinook Salmon

Founding broodstock for late-fall chinook salmon were selected from the indigenous population in the upper Sacramento River. Selection criteria applied to founding broodstock were based on location of capture, run timing and, likely, phenotypic (appearance) characteristics indicative of naturally spawning late-fall chinook salmon in the Sacramento River.

Broodstock selection criteria presently used for late-fall chinook salmon at Coleman NFH include run timing, phenotypic criteria, and hatchery mark status. All late-fall chinook salmon produced at Coleman NFH are marked with an adipose fin-clip and coded-wire tag. Unmarked (natural-origin) adults in Battle Creek are completely excluded from the late-fall chinook propagation program. Unmarked adult late-fall chinook collected at the Coleman NFH will be released during the initial sorting process to spawn naturally in upper Battle Creek.

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Beginning in 2002, natural-origin late-fall chinook from the Sacramento River will again be used as hatchery broodstock. Natural-origin late-fall chinook will be collected at the Keswick fish trap, and will be differentiated from early-arriving winter chinook salmon based on phenotypic (appearance) criteria including degree of ripeness and coloration. When a run call cannot be easily determined based on phenotypic criteria, a tissue sample will be collected and the results of genetic analysis will determine run identity.

Late-fall chinook broodstock at Coleman NFH are randomly selected from the total number of ripe adults >650 mm FL collected at the hatchery on Battle Creek. Jacks (males < 650 mm FL; approximately age-2) are incorporated as broodstock at a rate of 5% of the number spawned.

Winter Chinook Salmon
To protect the genetic integrity of the winter chinook population, selection of winter chinook broodstock is accomplished by screening collected adults using several diagnostic criteria. These criteria were developed to reliably discriminate winter chinook salmon from non-target stocks. To be selected as winter chinook broodstock at Livingston Stone NFH, an adult salmon must satisfy phenotypic criteria (run and spawn timing, location of capture, physical appearance indicators) and genetic criteria (based on seven loci that provide a high-level of discrimination). In combination, the phenotypic and genetic criteria used to select winter chinook broodstock provide an accurate and precise discriminatory tool.

Steelhead Trout
For various reasons, longer steelhead tout broodstock have been selectively spawned at Coleman NFH for many years. In the early 1950's, longer adults were preferentially selected for spawning because hatchery-origin steelhead trout were thought to be short, and because longer steelhead trout were desired for the Sacramento River sport fishery. Beginning in 1986, exclusive selection for longer (>554 mm) steelhead trout broodstock was instituted to "breed out" characteristics of non-anadromy believed to exist from speculated crosses between steelhead and non-anadromous rainbow trout (USFWS 1979). Scale analysis conducted at that time suggested that steelhead "shorts" (<554 mm) may have actually been non-anadromous "river-trout," and an aggressive broodstock selection program was implemented to breed out the non-anadromous trait.

In the mid-1990's, after nearly a decade of excluding steelhead <554 mm from spawning at Coleman NFH, shorter steelhead trout continued to be abundant in the returning hatchery population. At that time the Service began to re-examine (using scale analysis, coded-wire tag returns, and growth rates) the practice of length-based broodstock selection. Throughout this examination, several inconsistencies were noted with the theory of non-anadromy for steelhead shorts: 1) length-at-age data suggested that growth rates of steelhead trout shorts were substantially greater than those typical of resident trout in the upper Sacramento River (unpublished data, CDFG, Redding, CA); 2) research showed that returning hatchery-origin steelhead trout at Coleman NFH were not smaller than indigenous steelhead trout populations existing prior to hatchery influences (Hallock 1989); and, through otolith micro-chemistry, it was verified that steelhead trout shorts returning to Coleman NFH are predominantly anadromous (unpublished data, USFWS, Red Bluff, CA).

With this new information, steelhead trout shorts were re-incorporated as broodstock in 1999. Research is currently being conducted to determine necessary changes in spawning, incubation, and rearing practices to incorporate the entire length distribution of returning steelhead trout as broodstock. In this research, steelhead "longs" and "shorts" are being experimentally crossed to investigate possible differences associated with length. Resulting progeny are monitored for survival, growth, and contribution as adults. Information generated through this investigation will be used to support incorporation of steelhead trout from the entire size distribution collected at Coleman NFH.

6.8 Risk aversion measures to minimize the likelihood of negative impacts on naturally-produced salmonids

Several measures are taken reduce the chance of negative impacts to natural salmonids. High levels of integration between hatchery- and natural-origin fall chinook salmon will reduce the risks of genetic divergence and domestication, and are intended to reduce the potential for negative genetic impacts to natural populations (see Appendix 6D for a more complete discussion of genetic risks to natural populations associated with hatchery propagation efforts). Broodstock collection and selection methods are designed to prevent the use of non-target fish as hatchery broodstock, reducing the risk of hybridization between stocks. In addition, genetic variability will be maintained by collecting and spawning adults throughout the duration of natural run/spawn timing. Specifics for each stock are discussed below.

Natural Fall Chinook Salmon

The large number of fall chinook broodstock used at Coleman NFH (approx. 5,000) should serve to reduce the potential for genetic drift by the hatchery population. Furthermore, because of the large number of fall chinook salmon spawned at the hatchery, it is unlikely that there has been a substantial loss of heterozygosity (Ryman and Ståhl 1980). In instances where allele frequency instability between years in hatcheries has been noted (i.e., loss of heterozygosity), it was attributed to the use of an effective number (N_e) of parents of less than 50, even though the actual number of returning adults was much higher (Waples and Teel 1990). Maximization of N_e is critical, as high levels of inbreeding depression and loss of genetic variability can be experienced within populations of small effective population size (Hard et al. 1992). The rate of inbreeding per generation is proportional to the inverse of $2N_e$ (Ryman and Ståhl 1980) and is substantially greater at low N_e (Figure 6-1). However, opinions regarding an acceptable minimum value of N_e are varied (Tave 1986, Waples and Teel 1990, Simon 1991).

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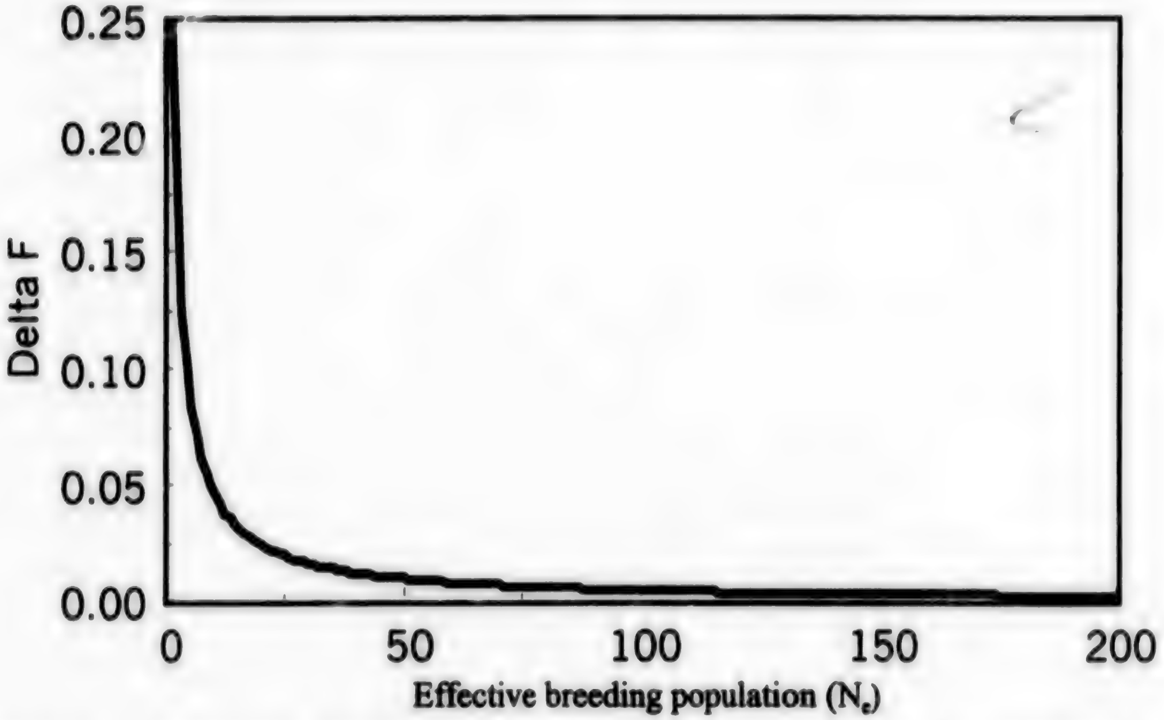

Figure 6-1. Increase of inbreeding per generation (Delta F) as a function of the number of effective parents (N_e) (from Ryman and Ståhl 1980).

Natural Late-fall Chinook Salmon

Late-fall chinook salmon at Coleman NFH are considered to be genetically similar to natural-origin late-fall chinook salmon in the upper Sacramento River and negative genetic impacts from the propagation program are, therefore, unlikely. Coleman late-fall chinook salmon were selected from the indigenous population of late-fall chinook in the upper Sacramento River. Founding broodstock were selected based on location of capture, run timing, and phenotypic (appearance) characteristics indicative of naturally spawning late-fall chinook salmon in the Sacramento River. Similar to fall chinook, the large number of late-fall chinook broodstock used at Coleman NFH (approximately 540) will serve to reduce risk of genetic drift and maintain heterozygosity in the hatchery stock (Figure 6-1). Broodstock collection and selection strategies are in place to exclude non-target adults from the late-fall chinook spawning process. Hatchery spawning of late-fall chinook salmon extends through the duration of natural spawn timing. Natural-origin late-fall chinook salmon have been regularly incorporated as hatchery-broodstock

Natural-origin late-fall chinook salmon will again be incorporated as hatchery broodstock beginning in 2002. Incorporation of natural-origin adults will be conducted to reduce genetic risks including loss of diversity among populations, domestication, and divergence between hatchery and natural stocks. Additional integration with the naturally-producing population in the Sacramento River will result from straying by hatchery-origin adults (see Section 10.12 and Appendix 10C for discussion on straying, see Appendix 6D for discussion of genetic impacts to the natural population).

Natural Winter Chinook Salmon
The winter chinook salmon supplementation program was developed to minimize the risk of extinction and support recovery of the ESA-listed stock. Winter chinook salmon are collected and spawned throughout the duration of run/spawn timing to maintain variability. Risk aversion measures such as phenotypic and genetic selection criteria are briefly explained in sections 7-4 and 7-9, and are fully described in USFWS (1996), USFWS (1998a), and USFWS (1998b). A factorial-type spawning scheme is used to increase the effective population size of hatchery winter chinook salmon.

Natural Spring Chinook Salmon
It has been suggested that hybridization between fall and spring chinook has occurred during fall spawning operations at Coleman NFH. Potential hybridization between fall and spring chinook salmon at Coleman NFH has been assumed based on failure of Hardy/Weinberg Equilibrium (H/W E) testing of allele frequencies in 1993 and 1995 (Banks et al. 2000). Failure of H/W E was also noted for tissue samples from fall chinook salmon carcasses collected in the mainstem Sacramento River in 1995.

Mathematical questions surrounding population sizes of spring chinook salmon in Battle Creek have been raised. For example, Banks et al. (2000) report that ten individuals were removed from the 1993 samples without rectifying disequilibrium. Banks et al. (2000) also reported H/W E failure for 1995. For this year, tissue samples that were collected for genetic analysis came from 95 spawned adults collected throughout the course of the early-October though late-November fall chinook spawning period (approximately ⅓ from early, mid, and late each). Despite the removal of 24 individuals determined to be non-fall run origin, significant linkage disequilibrium remained (Banks et al. 2000). The total Battle Creek estimate for fall chinook salmon in 1995 was approximately 75,000. Therefore, if random sampling throughout the run yielded a 24:95 (~ 1:4) spring to fall chinook salmon ratio, approximately 18,000 spring chinook salmon would have had to be present in lower Battle Creek, and the majority of those would have spawned in October. Although spawn timing of spring chinook salmon can occur through October, the current peak spawning period is thought to be late-September (CDFG 1998). Even if only two of the 95 fish randomly sampled were spring run (2:95 spring to fall ratio), almost 1,600 spring chinook would have had to be present in lower Battle Creek. Existing monitoring programs, however, suggest current population sizes are no greater than100 (see Section 2.10), while the predicted population size of spring chinook salmon in Battle Creek following full restoration (~ year 2005 plus) is estimated at 2,500..

While spring chinook salmon could be inadvertently spawned with fall chinook salmon at Coleman NFH, recent modifications to Coleman barrier weir operations should greatly reduce this possibility. To help separate fall and spring chinook salmon, the timing of Coleman barrier weir operations has been modified. Spring chinook are currently afforded passage past the Coleman barrier weir throughout the majority of their migration. Information on migration timing of spring chinook salmon in Battle Creek is currently not available; however, general spring chinook salmon migration into natal streams occurs from mid-February through July, with

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the peak occuring May (CDFG 1998). If spring chinook are allowed access to upper Battle Creek, the probability of encountering them during fall broodstock collection and spawning, and thus the probability of hybridization, should be greatly reduced.

Natural Steelhead Trout

Genetic drift will be minimized by using a large number of broodstock (approximately 400). Variability of run/spawn timing is maintained by spawning steelhead trout from throughout the entire distribution of natural spawn timing. Steelhead trout will be spawned from the entire size distribution of returning adults to reduce the likelihood of negative genetic effects including directional selection and inbreeding. Incorporation of natural-origin steelhead trout will decrease the potential for negative genetic impacts that could result from isolated hatchery and natural populations (i.e., domestication, loss of diversity, and inbreeding; see Appendix 6D for a more complete discussion of genetic concerns).

Negative effects are unlikely to occur to naturally-spawning steelhead trout in Battle Creek as a result of hatchery broodstock collections. The existing naturally spawning steelhead trout population in Battle Creek was founded with hatchery-origin adults from Coleman NFH. During recent years substantial numbers of hatchery-origin steelhead trout have been passed above the Coleman barrier weir to re-establish a naturally spawning population in Battle Creek. In future years, all steelhead trout collected at Coleman NFH in excess of broodstock needs will continue to be released above the barrier weir to spawn naturally in Battle Creek. Natural production by hatchery-origin steelhead trout in upper Battle Creek should be more than sufficient to offset the periodic collection of 50 natural-origin returning adults.

BROODSTOCK COLLECTION

7.1 Life-history stage to be collected

Broodstock for fall, late-fall, and winter chinook salmon and steelhead trout are collected as adults and spawned in either Coleman NFH (fall and late-fall chinook salmon and steelhead trout) or Livingston Stone NFH (winter chinook salmon).

7.2 Congregation and collection of broodstock

Fall and Late-fall Chinook Salmon and Steelhead Trout at Battle Creek

The Coleman barrier weir and its associated fish ladders are located approximately 5.5 miles upstream from Battle Creek's confluence with the Sacramento River. The weir is permanent, and extends across the full width of Battle Creek (approximately 90 feet). The barrier weir obstructs passage of adult salmonids to upper Battle Creek (above the hatchery) and diverts them to a fish ladder leading to the hatchery's adult holding ponds. This method of broodstock collection is believed to provide a representative (unbiased) sample of all adults attempting to ascend Battle Creek past the Coleman NFH. Adults that do not enter the hatchery's holding ponds may attempt passage at the barrier weir, remain in lower Battle Creek and spawn naturally, or return downstream to the Sacramento River. Non-salmonid fishes are seldom captured in the hatchery's holding ponds because the step-type design of the fish ladder prohibits their entry.

In the unlikely event that an emergency situation prohibits broodstock collections in Battle Creek, the adult fish traps at the RBDD and the Keswick Dam could also be used to collect fall chinook salmon and steelhead trout broodstock directly from the Sacramento River. Historically, the Coleman stock of steelhead trout was founded from adults captured at the Keswick fish trap, and collections of adults from that location were regularly used to supplement returns to Battle Creek through 1986. The adult fish trap at RBDD was used for collecting all fall chinook broodstock during the drought years of 1978 and 1979. During those years, migration of fall chinook was blocked at the RBDD to prevent them from entering habitats unfavorable for spawning. However, barring a catastrophic occurrence in Battle Creek, the Service does not currently propose to operate the traps at Keswick Dam or RBDD for collecting fall chinook salmon or steelhead. trout. The structure and operation of the Keswick and RBDD fish traps are discussed in section 5.2 and on page 7-5.

Escapement Above the Barrier Weir

Even when upstream passage is blocked, the Coleman barrier weir is not completely effective at preventing passage of adult salmonids in Battle Creek. The rate of escapement above the barrier weir is positively related to the number of attempts to jump over the barrier weir and may also be partially dependent on water flow in Battle Creek. At flows < 350 cfs, the laminar flow over the apron of the barrier weir is too shallow for most salmonids to gain enough speed to jump the height of the weir. The fish that do manage to jump the barrier weir at low flows are likely smaller-bodied chinook salmon, especially jacks, and steelhead trout which have superior leaping abilities. At flows above 350 cfs, the laminar flow over the barrier weir's apron increases, and significant numbers of salmon and steelhead trout may pass into upper Battle Creek. The mean monthly discharge of Battle Creek increases from nearly 300 cfs in October to over 700 cfs during the month of January (Ward and Kier 1999); therefore, some escapement into upper Battle Creek is possible during most of the broodstock collection at Coleman NFH. The Coleman barrier weir is currently being re-designed, in part to improve fish blocking capabilities under all flow conditions.

Environmental conditions are unfavorable for conducting field assessments during broodstock collection, when high flows (and potentially high levels of escapement) occur in Battle Creek. Consequently, the extent of annual escapement over the Coleman barrier weir has not been directly determined. Observations, however, made in 1995 suggest that approximately 2500 fall chinook salmon successfully traversed the barrier weir in that year (Campbell et al. 1995). This equates to roughly 3% of the total fall chinook salmon escapement estimate to Battle Creek in that year. An indirect assessment of the number of female salmonids escaping over the Coleman barrier weir can be made by evaluating productivity of adult salmonids escaping to, and spawning in, upper Battle Creek. The Service (RBFWO unpublished data) has estimated juvenile production of fall chinook salmon above Coleman NFH to be 1,508,543 for brood year 1998 and 287,423 for brood year 1999. From these data, the numbers of female fall chinook salmon spawning above Coleman were estimated at 1207 in 1998 and 229 in 1999, assuming an average of 5,000 eggs per female (USFWS unpublished data) and 25% egg to fry survival. These estimates of escapement above the barrier weir correspond to years of substantial over-escapement of fall chinook salmon to Battle Creek. The total number of fall chinook salmon spawning naturally in Battle Creek and collected at Coleman NFH was 98,308 in 1998 and 119,019 in 1999. This suggests the Coleman barrier weir was effective at blocking over 98% of the fall chinook salmon from ascending Battle Creek past Coleman NFH.

Evidence of escapement past the barrier weir by late-fall chinook salmon was lower than expected. It was previously considered that late-fall chinook salmon were more likely to escape past the barrier weir than fall chinook salmon because flow rates are generally higher during the migration of late-fall adults. However, the juvenile production estimate for late-fall chinook salmon in upper Battle Creek was 193 for brood year 1999. Data for brood year 1998 were incomplete, but more late-fall juveniles were captured in brood year 1998 (n = 26) than brood year 1999 (n = 10). Estimating numbers of late-fall female spawners escaping over the barrier weir is not appropriate for brood year 1998 or 1999 given such low juvenile production estimates; however, it is reasonable to assume that the numbers of spawners were quite low. These data, while not direct measures of adult escapement past the barrier weir, corroborate the belief that the existing structure is not completely effective at blocking escapement into upper Battle Creek. Nevertheless, the Coleman barrier does appear to be effective at blocking the majority of adults from accessing upper Battle Creek.

Timing of Broodstock Collection at the Barrier Weir
Upstream passage is blocked at the Coleman barrier weir from September 1 through early March. From early-March through August, fish are allowed to ascend Battle Creek past the barrier weir through an upstream fish ladder.

To obtain a representative sample of each stock, fall and late-fall chinook salmon and steelhead trout broodstock are collected at Coleman NFH throughout the duration of spawn timing (Figure 7-1). Collection of fall chinook broodstock begins two or three days before the initial spawn date in mid-October and continues through the final spawn date in late-November. Late-fall chinook broodstock are collected from mid-December through late-February or early-March. Collection of steelhead broodstock occurs concurrently with collection of fall and late-fall chinook salmon, beginning in October and continuing through mid-February. In recent years, 50-60% of the returning steelhead trout population has arrived at Coleman NFH by mid-December.

Between collections of fall and late-fall chinook salmon broodstock (approximately four weeks between Thanksgiving and Christmas), the fish ladder into the hatchery is opened intermittently. Hatchery-origin steelhead collected during this time are retained as potential broodstock. Fall and late-fall chinook salmon collected during this time are culled. This practice promotes divergence in spawn timing between hatchery stocks of fall and late-fall chinook salmon to minimize the risk of hybridization between these stocks (Hankin 1991).

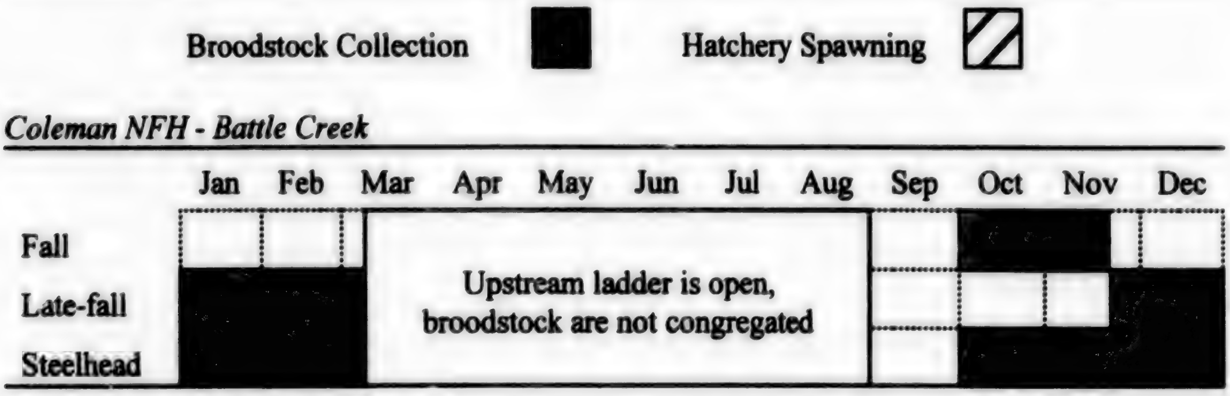

Figure 7-1. Schematic showing seasonal timing of broodstock collection and spawning at Coleman National Fish Hatchery. The upstream ladder is opened from early-March through August 31.

Additional Functions of the Barrier Weir
Additional functions of the Coleman NFH barrier weir include managing and monitoring passage of adult salmonids into upper Battle Creek. Historically, the Coleman NFH barrier weir has been utilized to restrict and monitor upstream passage of adult salmonids, outside of the time of broodstock collection, in order to accomplish the following objectives:

1. minimize the potential for hybridization between co-occurring, naturally-reproducing runs of chinook salmon in upper Battle Creek (e.g., fall and spring chinook);
2. minimize risk of IHNV being shed into the Coleman NFH water supply; and,
3. monitor passage of salmonids.

From about 1995 through 1999, the Coleman NFH barrier weir was closed beginning on or about July 1 to restrict upstream passage of early-arriving, hatchery-origin fall chinook salmon. The barrier weir remained blocked to upstream passage through the month of February to complete collections of fall and late-fall chinook salmon and steelhead. From early-March through June, fish passage into upper Battle Creek was afforded by opening the upstream fish ladder, located on the north side of the barrier weir. This period of passage was intended to accommodate the primary migration timing of spring chinook salmon. It also encompasses part of the migration timing for winter chinook salmon, late-migrating steelhead, pacific lamprey, and non-anadromous fishes.

Previous situations warranting closure of the upstream fish ladder on July 1 will be largely rectified through construction of the ozone water treatment facility at Coleman NFH and improvements to flow and fish passage associated with Battle Creek restoration including: 1) five unscreened hydropower dams operated by Pacific Gas and Electric will be decommissioned; 2) three additional hydropower dams will be screened and laddered; and, 3) instream flows will be increased. In light of these improvements, the fishery management agencies (USFWS, NMFS, CDFG) developed a new operational plan for the Coleman barrier weir. During 2000, the upstream ladder remained open until September 1, when it was closed to begin congregating fall chinook broodstock. This action is consistent with efforts to afford additional passage opportunity for spring chinook salmon, and increases passage opportunity by two months over previous years.

Anadromous fish spawning and rearing habitat upstream of the Coleman barrier weir contains designated critical habitat for steelhead trout and spring chinook salmon, and potentially restorable habitats for ESA listed winter chinook salmon. All of these stocks are primary target species/runs for the Battle Creek restoration project. Restoration of the Battle Creek watershed requires that target stocks of salmon and steelhead be afforded the opportunity to access the upper reaches of Battle Creek at the proper times. Additionally, restoration of target species in upper Battle Creek may require limiting access of relatively abundant salmonid stocks to the upper reaches of Battle Creek.

The present configuration and future operational strategy of the Coleman NFH barrier weir are currently under investigation by a multi-agency team assembled by the BCWG. The physical structure and operational strategy of the barrier weir will be modified, as necessary, to accommodate the Battle Creek restoration program. Future operations of the Coleman NFH barrier weir will be adapted to integrate with restoration activities in Battle Creek. As part of a successful integration strategy, upstream passage of anadromous salmonids will be blocked for purpose of collecting broodstock of fall and late-fall chinook salmon and steelhead trout only for the period September 1 through early-March. At all other times, the Coleman barrier weir fish ladder will be operated in a manner, to be recommended by the BCWG, such that restoration potential for target stocks is achieved in Battle Creek. Operational needs at Coleman NFH will not be considered sole justification for restricting upstream passage during times when broodstock are not being congregated or collected. Previous and future operational strategies for the Coleman NFH barrier weir are shown graphically in Figure 7-2.

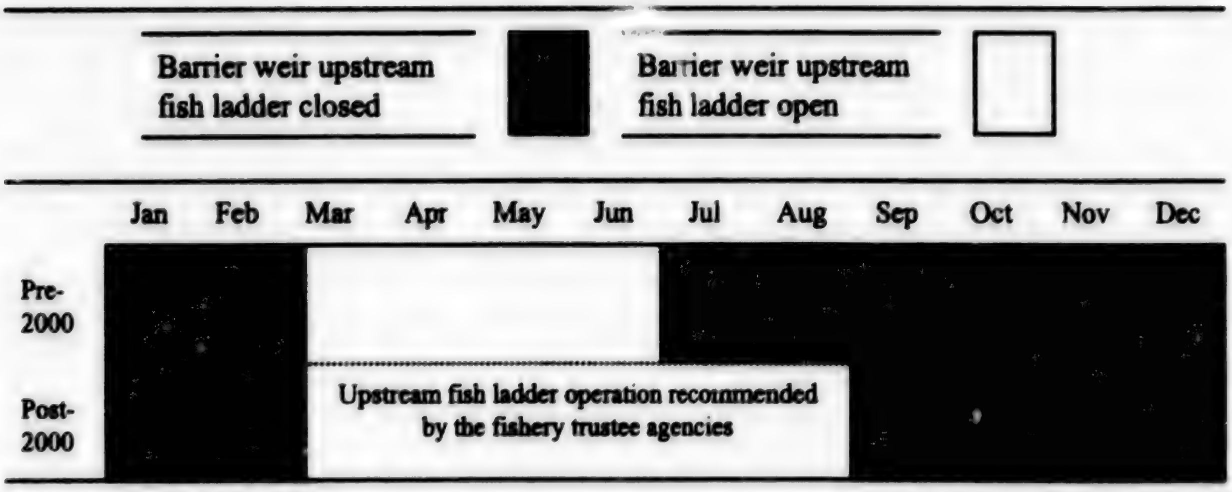

Figure 7-2. Generalized schedule of Coleman barrier weir upstream fish ladder operation pre-Battle Creek Restoration and proposed strategy for barrier weir upstream fish ladder operation to integrate with the Battle Creek Restoration process, beginning in 2000. Proposed strategy for operating the upstream fish ladder post-restoration calls for the upstream fish ladder to remain closed only during periods when hatchery broodstock are being congregated or collected, from September 1 through early-March.

Winter and Late-fall Chinook Salmon from the Sacramento River

Broodstock for the winter chinook salmon propagation program will be collected from the upper Sacramento River. Most of the broodstock is collected using the fish trap at Keswick Dam (RM 302). The fish trapping facilities at the Keswick Dam are located in the center of the dam, between the powerhouse and the spillway. The trapping facilities consist of a twelve-step upstream fish ladder, a brail-lift, and a 1,000 gallon elevator. The fish ladder is approximately 170 ft long and 38 feet wide. Weirs spaced every 13 feet 7 inches create pools in the ladder. Fish approaching Keswick Dam are attracted to the fish ladder by means of a 340 cfs jet pump supplying water to the trap and fish ladder. Additional attraction is supplied through water diffusers in the ladder floor. The top of the ladder leads to a fyke weir.

After passing through the fyke weir, adult salmonids are contained in a large fiberglass brail enclosure. Fish collected at the Keswick Dam fish trap remain in water at all times. When the trap brail is raised, trapped fish are directed into a 1,000-gallon fish tank elevator which transports them up the face of the dam. The fish tank elevator is then dumped into a vehicle equipped with a distribution tank and transported to Livingston Stone NFH.

Another fish trap located at RBDD is also used for capturing winter chinook salmon if the number of adults collected from the Keswick trap is not sufficient to meet hatchery broodstock goals. The RBDD has three fish ladders. One ladder is located on the east bank of the river, another is located on the west bank, and the third ladder is in the center of the dam itself. A fish trap is located on the east ladder, and is operated while the gates are in place (May 15 through September 15). When the trap is operating, fish ascending the east ladder are diverted (by a weir) into an examination area after jumping two false weirs. In the examination area, captured fish are anaesthetized with CO_2 and adult chinook salmon are phenotypically identified to run. Targeted chinook salmon are sorted from non-target salmon, netted from the trap, and detained for approximately one hour in the fish ladder in a flow-through retention tube prior to transport. Occasionally, chinook salmon of a specific gender will be targeted for collection at RBDD. For example, spawning goals at Livingston Stone NFH may require only males to be collected at RBDD if the number of males collected at Keswick Dam is not adequate to meet winter chinook program goals.

Beginning in 2002, the Service will re-initiate periodic collection of natural-origin late-fall chinook salmon for spawning at Coleman NFH. Natural-origin late-fall chinook salmon do not return to Coleman NFH in large enough numbers to fulfill broodstock requirements (n < 25), so they will be collected from the upper Sacramento River. Late-fall chinook salmon will be collected using the Keswick fish trap, in the same manner as winter chinook salmon.

Escapement and Passage Above Red Bluff Diversion Dam and Keswick Dam
Gates are in at the RBDD from May 15 through September 15. During that time, migration of salmonids (and other fish) may be blocked or delayed. The RBDD has three fish ladders, and migrating salmonids must use the associated fish ladders to pass the dam. Because RBDD has three fish ladders and only one ladder has a fish trap, all salmon passing the dam are not captured in the fish trap.

The Anderson-Cottonwood Irrigation District (ACID) Dam, located three miles downstream from Keswick Dam, is installed from May to October. Migration delays or blockage at the ACID Dam may reduce the number of winter chinook adults reaching the Keswick Dam fish trap. The ACID Dam fish ladders have recently been re-designed to facilitate improved fish passage.

Keswick Dam is an impassable barrier to fish migration. The fish ladder associated with Keswick Dam leads directly into a fish trap. When broodstock collection is not in progress, water flow to the fish ladder is stopped and the fish ladder is closed. Estimated escapement from the fish ladder and associated fish trap is not known, but is presumed to be small.

Timing of Broodstock Collection

Collection of late-fall and winter chinook salmon at the Keswick Dam fish trap will be conducted to sample the entire duration of migration timing (Figure 7-3). Collection of late-fall chinook at the Keswick fish trap will begin in early-December and continue until early-March. Collection of winter chinook salmon at the Keswick fish trap will begin in early-December and continue into July. Winter chinook salmon migration and the operation of RBDD only overlap from mid-May through mid-July. Therefore, collection of winter chinook salmon at RBDD, when necessary, can occur only at the end of the winter chinook migration.

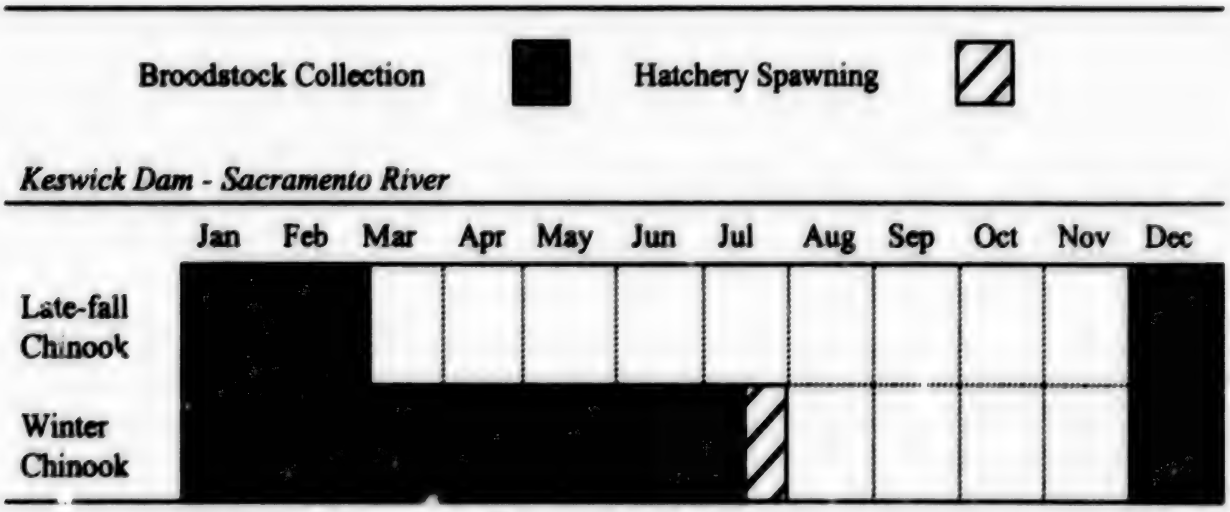

Figure 7-3. Generalized periods of broodstock collection and spawning for late-fall and winter chinook salmon collected at the Keswick Dam fish trap on the Sacramento River.

7.3 Broodstock transportation and holding methods

Fall Chinook Salmon

Transportation

Coleman NFH is located on Battle Creek, and the hatchery's broodstock is taken directly from the creek. Because of this, transport of hatchery broodstock is usually unnecessary. In the event of an emergency and broodstock from Battle Creek are not available, broodstock may be collected from Keswick and RBDD fish traps. Transportation of broodstock collected from these fish traps is discussed in the following section on late-fall chinook salmon.

Holding and Sorting

Duration of residence in the hatchery ponds prior to sorting of collected fishes varies from one to seven days, depending on the time of entrance into the hatchery ponds and the schedule of hatchery spawning. Generally, fall chinook salmon are initially sorted within one or two days after collection in the holding ponds. Pre-spawning mortality for fall chinook salmon prior to the initial sort is unknown, but total prespawning mortality (including fish sorted and held for spawning at a later date) ranged between 4.2 and 13.5% (mean 8.7%) for brood years 1996 through 2000. Mortality prior to the initial sort is therefore lower than this, and is probably in the range of 2-4% because of favorable environmental conditions, low holding densities, and frequent spawning events.

During the initial sorting/spawning event, a sufficient number of ripe fish are spawned to meet daily egg-take projections. For sorting, collected fish are routed into the spawning building using mechanical weirs and crowders. A hydraulic lift located in the spawning building raises fish into a CO_2 anaesthetization tank. Anaesthetized fall chinook salmon are phenotypically sorted into one of three categories: 1) ripe fish to be spawned, 2) fish to be culled (excessed), or 3) unripe fish to be held for possible spawning at a later date, Fall chinook salmon that are ready to be spawned are spawned that day. Excess salmon are culled immediately. Unripe fish are held at the end of the migration for a relatively short time (<10 days). This is done to ensure that sufficient broodstock will be available at the end of the spawning season. Fish held for future spawning are shunted into one of two additional holding ponds located inside the spawning building. They are sorted during subsequent spawning events. Steelhead trout and late-fall chinook salmon broodstocks are collected concurrently with fall chinook salmon. The disposition of these fish is discussed in the sections concerning late-fall chinook salmon and steelhead trout.

Late-fall Chinook Salmon

Transportation

Coleman NFH is located on Battle Creek, and most of the hatchery's broodstock is taken directly from the creek. Because of this, transport of most of the late-fall chinook salmon broodstock is unnecessary. However, the Service will begin periodic collection of natural-origin late-fall chinook salmon at the Keswick Dam fish trap for spawning at Coleman NFH in 2002. These fish will be transported from the Keswick Dam to Coleman NFH.

Late-fall chinook salmon collected at the Keswick Dam will be transported to Coleman NFH after separation from other fish that are captured. Fish captured by the Keswick Dam fish trap are transported in one of two 1200-gallon, insulated fish hauling trucks. At the Livingston Stone NFH, most of the water is drained from the transport tank and CO_2 is infused to anaesthetize collected fish. Phenotypic characteristics are used to sort chinook salmon into stocks (late-fall, winter, or spring, depending on time of year). After sorting, the transport tank is re-filled with fresh water to transport chinook salmon identified as late-fall to Coleman NFH. Non-target fish (primarily *O. mykiss*) collected at the Keswick fish trap are segregated and released into the upper Sacramento River near suitable spawning habitats. Salmon and steelhead will be relocated to one of four possible sites, depending on water levels, time of year, and phenotypic run identification. Possible spring chinook salmon will be relocated to the Sacramento River at Bend Bridge (RM 258), so they have an opportunity to ascend Battle Creek or remain in the mainstem. After the ACID Dam is installed for the year (mid-April), all fish will be relocated to Caldwell Park (RM 299). If the ACID Dam has not been installed and water levels are low, salmon may be relocated to the Bonnyview Boat Ramp (RM 292) or the Posse Grounds (RM 298). Salt, artificial slime, and ice may be added to transport water at standard rates to reduce stress during transport.

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Estimated time to transport late-fall chinook salmon from Keswick Dam to Coleman NFH varies depending on the number and types of fish captured by the fish trap. Total transit time from Keswick Dam to Coleman NFH ranges from two to four hours. Transport from Keswick Dam to Livingston Stone NFH is less than one hour. Sorting of fish may take up to two hours. Transport of late-fall chinook salmon from Livingston Stone NFH to Coleman NFH is less than one hour.

Holding and Sorting

Late-fall chinook salmon collected from Battle Creek may reside in the hatchery's holding ponds one to seven days before initial sorting. Generally, initial sorting of late-fall chinook salmon occurs within one or two days after collection in the holding ponds. Pre-spawning mortality for late-fall chinook in the holding ponds prior to the initial sort is unknown, but is likely lower than fall chinook (< 4%) because of more favorable environmental conditions (e.g., lower water temperatures), lower holding densities (returns are much lower for late-fall chinook), and frequent spawning events. Late-fall chinook salmon captured at the Keswick Dam fish trap will be transported to Coleman NFH where they will be held until spawned (1 - 7 days). Time spent in the holding ponds depends on the time of entrance into pond and the schedule of hatchery spawning. The sorting procedure for late-fall chinook salmon is similar to that described previously for fall chinook salmon (page 7-8).

Adipose fin-clipped late-fall chinook salmon collected from Battle Creek are sorted into three categories: 1) ripe fish to be spawned, 2) fish to be excessed, or 3) unripe fish to be held for possible spawning at a later date. Unripe late-fall chinook salmon are frequently held for spawning at a later date. This helps to ensure there will be enough broodstock available to meet spawning goals at the end of the season. Any late-fall chinook salmon returning to Battle Creek that are not fin clipped are returned to Battle Creek during the initial sort process by shunting them down a tube emptying into Battle Creek above the hatchery's barrier weir. Unmarked late-fall chinook salmon collected at Keswick Dam will be spawned when ripe or held for spawning at a later date, they will not be excessed.

Winter Chinook Salmon

Transportation

Winter chinook salmon are collected at the Keswick Dam fish trap, and, if necessary, at the RBDD fish trap. Transportation and sorting of fish collected at the Keswick Dam fish trap have been described previously in the section on late-fall chinook salmon transportation.

If broodstock goals cannot be met through collection of chinook salmon at the Keswick fish trap, winter chinook salmon may be collected at the RBDD fish trap. Winter chinook salmon are collected at RBDD in conjunction with passage monitoring conducted by the CDFG in the dam's east fish ladder. Because the RBDD gates do not go in until mid-May, winter chinook salmon can only be collected at the end of their migration at this location. Adults collected in the fish trap at RBDD are transported to Livingston Stone NFH in a fish distribution vehicle carrying an aerated 250-gallon insulated transport tank. Salt, artificial slime, and ice may be added to transport water at standard rates to reduce stress during transport.

Holding and Sorting

Upon arrival at Livingston Stone NFH, phenotypically identified winter chinook salmon collected from RBDD are anaesthetized, length and gender are recorded for each fish, and a tissue sample is collected for genetic identification. A color-coded and alphanumeric floy tag is attached to the salmon just below the dorsal fin for individual identification. Tagged fish are then placed into quarantine tanks and tissue samples are sent for "rapid-response" genetic analysis and run determination (see Appendix 6C). Adult salmon genetically identified as winter chinook salmon are transferred into one of two 20-foot circular holding tanks. The holding tanks are connected to a carbon filter for detoxification of malachite green following prophylactic and therapeutic antifungal treatments of broodstock.

Hatchery-origin (adipose fin-clipped) chinook salmon identified as "non-winter" will then be sacrificed for coded-wire tag (CWT) recovery and verification of the genetic call. Hatchery-origin chinook salmon genetically identified as winter chinook are either: 1) relocated to the mainstem Sacramento River (if not needed for the propagation program); 2) retained for the hatchery propagation program; or, 3) sacrificed for CWT extraction and verification of genetic call. Natural-origin (unmarked) winter chinook salmon are placed into the adult holding tank and retained for the propagation program. Hatchery-origin winter chinook salmon may only be incorporated as 10% of the broodstock. Because of this, the proportion of hatchery-origin winter chinook salmon held as potential broodstock will not exceed 10% of the broodstock held at Livingston Stone NFH at any time. Winter chinook salmon not held for spawning (hatchery and natural) will be relocated to the mainstem Sacramento River at Caldwell Park (RM 299), the Posse Grounds (RM 298), or to Bonnyview Boat Ramp (RM 292). Relocation site depends on water levels and the time of year (whether or not the ACID Dam is in place). Most of the other unmarked chinook determined genetically to be non-winter chinook will also be relocated to the mainstem Sacramento River at the previously mentioned release sites. Unmarked chinook salmon collected during the late-fall migration genetically determined to be non-winter may be transported to Coleman NFH in some years. Floy tags attached to fish destined for relocation will not be removed, as information that may be gathered during carcass surveys would be valuable in assessing mortality rates of relocated fish.

Steelhead Trout

Transportation

Adult steelhead trout broodstock are collected and spawned at the Coleman NFH on Battle Creek; therefore, transportation of steelhead trout broodstock is not necessary.

Holding and Sorting

Steelhead trout collected from Battle Creek may reside in the hatchery's holding ponds for one to seven days before initial sorting. Generally, initial sorting of steelhead trout occurs within one or two days after collection in the holding ponds. Pre-spawning mortality of steelhead trout in the holding ponds prior to the initial sort is low, averaging 5% (range 2 to 9%) over the last five years (1997 through 2001; USFWS, Coleman NFH unpublished data). Mortality is low because of favorable environmental conditions, low holding densities, and frequent spawning events. In addition, steelhead generally arrive at the hatchery in good physical condition and well before they are ready to spawn.

Specifics of sorting methods are similar to those used for fall and late-fall chinook salmon and have already been described previously in the section on fall chinook salmon (page 7-8). Steelhead trout are sorted into one of three categories: 1) ripe and ready to spawn, 2) ready for release into Battle Creek above the barrier weir, or 3) unripe fish to be "banked" for spawning at a later date. In addition, most males that are spawned are later passed above the barrier weir into Battle Creek.

Steelhead trout collected from Battle Creek during the early part of their migration are usually unripe. Consequently, they are separated from chinook salmon and held for later spawning. This practice is called "banking." Steelhead trout broodstock is banked to ensure that overall hatchery egg-take goals will be achieved. After sufficient numbers of adults are retained in the hatchery's holding ponds to ensure broodstock availability, excess steelhead trout are afforded regulated passage above the hatchery into upper Battle Creek. With the current practice of "banking" steelhead trout broodstock, it is not possible to calculate the duration that any individual steelhead trout may be detained in the hatchery collection ponds. Theoretically, an individual steelhead trout captured during fall chinook spawning (e.g., mid-November) could spend longer than one month in the Coleman NFH holding ponds prior to being spawned at the hatchery or released upstream. However, even with extended residence in the hatchery ponds, steelhead mortality in the hatchery ponds is minimal due to favorable environmental conditions, separation from chinook salmon during holding, low holding densities, and a general proclivity for holding well in the hatchery ponds.

All marked (adipose fin-clipped) steelhead trout will be banked to meet broodstock goals. Beginning in brood year 2002, approximately 40 unmarked (presumably natural-origin) steelhead trout will be incorporated as broodstock at Coleman NFH. The Service will attempt to collect these unmarked steelhead across the spectrum of run timing.

7.4 Identifying target populations and hatchery- vs. natural-origin fish

During broodstock collection at Coleman NFH and Keswick and RBDD fish traps, as many as four different stocks of salmonids may be migrating at any one time. Consequently, non-target stocks are frequently collected in conjunction with hatchery broodstocks. In addition, natural-origin fish are frequently incorporated into hatchery broodstock, so hatchery- and natural-origin fish must also be distinguished. Identification and disposition of stocks encountered during collection of broodstock is described below:

Target Population: Fall Chinook Salmon

Hatchery- and natural-origin salmonids from different stocks co-exist with fall chinook in Battle Creek, and may be inadvertently collected in the hatchery ponds while collecting for fall chinook broodstock. Identification and disposition of non-target salmonids encountered during collection of fall chinook broodstock are described below:

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Natural-origin Fall Chinook Salmon

Fall chinook salmon entering Battle Creek and collected at Coleman NFH are of mixed-origin, resulting from artificial propagation at the Coleman NFH and natural production occurring primarily in lower Battle Creek (see section 6 on Broodstock Origin). Selection of fall chinook broodstock at Coleman NFH does not attempt to separate hatchery- and natural-origin adults. Because only a portion (approximately 8%) of fall chinook salmon juveniles released from Coleman NFH are currently marked (adipose fin-clip and CWT), differentiation between returning hatchery- and natural-origin adults is not feasible at the scale of individual fish. Both marked and unmarked fall chinook salmon are used as hatchery broodstock. Incorporation of natural-origin adults as hatchery broodstock serves to reduce domestication of the hatchery stock and also minimizes genetic divergence between hatchery and natural stocks.

Hatchery-origin Late-fall Chinook Salmon

Hatchery-origin fall and late-fall chinook salmon overlap temporally during their residence in Battle Creek and both may enter the hatchery ponds during collection of fall chinook broodstock. Typically, by the end of fall chinook spawning at Coleman NFH early-arriving late-fall chinook salmon comprise a substantial portion of adults collected at Coleman NFH (Figure 7-4).

Differentiation of hatchery-origin fall and hatchery-origin late-fall chinook salmon is accomplished during the initial sorting process based on mark status (adipose fin clip) and physical appearance (including coloration, amount of fungus, and degree of ripeness or "firmness"). Since 1995, fall chinook salmon smolts released from Coleman NFH have been marked with an adipose fin-clip and CWT at a rate of approximately 8%. Late-fall chinook originating at Coleman NFH have been 100% marked and tagged since 1992[1]. Therefore, differentiation between co-occurring hatchery-origin fall and late-fall chinook salmon is facilitated by observing presence or absence of an adipose fin.

Physical appearance criteria are used to further differentiate the marked portion (~8%) of hatchery-origin fall chinook from hatchery-origin late-fall chinook salmon. For example, broodstock selection criteria in effect during the final few spawn dates for fall chinook salmon (in late-November) select *against* adults that are bright, firm, and adipose fin-clipped (indicating they are possibly early-arriving late-fall chinook). Alternatively, broodstock selection criteria during the first few late-fall chinook spawning dates (late-December) select *against* adults that are dark, over-ripe, unclipped (indicating they are possibly late-arriving fall chinook), and have excessive amounts of fungus. Hatchery-origin late-fall chinook salmon encountered during the fall chinook spawning process are culled.

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[1] In 1998, approximately 125,000 unmarked late-fall chinook juveniles were placed in the hatchery's pollution abatement pond. Evidence suggests that substantial numbers of these fish (est. 50,000) exited the pond through a spillway and entered Battle Creek.

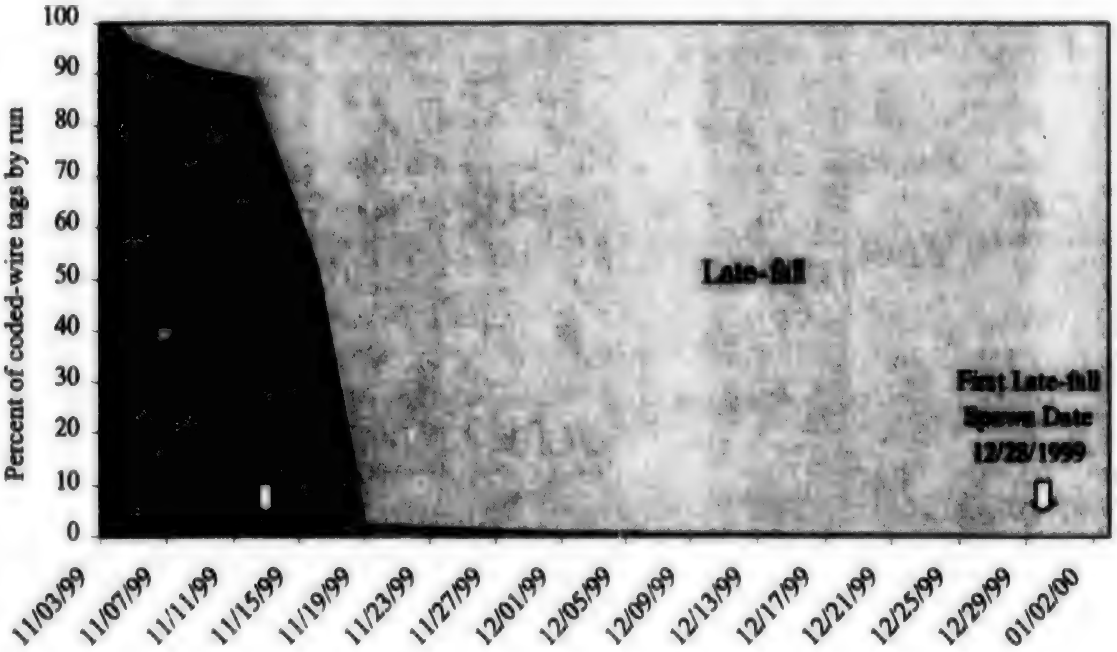

Figure 7-4. Transition from fall to late-fall migrations of adult chinook salmon at Coleman National Fish Hatchery, Battle Creek, California. Data are from coded-wire tag recoveries from November 1999 through January 2000.

While not completely failsafe, the mark-status and physical appearance indicators used to differentiate hatchery-origin fall and late-fall chinook at Coleman NFH exclude nearly all late-fall adults from the fall chinook spawning process. Effectiveness of these procedures has been verified through recoveries of CWT's from marked salmon spawned during the 1991 to 1998 spawning seasons. Over those years, an average of 1.7 hatchery-origin late-fall chinook annually (range: 0 to 6) were mis-identified and inadvertently included with fall chinook spawners. The largest incorporation of late-fall chinook into fall chinook spawning occurred in 1993, when six late-fall chinook were incorporated with the total 6,257 fall chinook salmon spawned at Coleman NFH. This equals less than one-tenth of one percent (0.096%). During that year, selection criteria for fall chinook broodstock were more relaxed at Coleman NFH and did not consider mark status to differentiate between hatchery fall and late-fall chinook.

Natural-origin Late-fall Chinook Salmon

Natural-origin late-fall chinook salmon encountered during the fall chinook spawning process are identified and separated from fall chinook salmon on the basis of physical appearance. Broodstock selection criteria in effect during the end of fall chinook spawn timing (e.g., late-November) select *against* traits characteristic of early-arriving late-fall chinook adults (e.g., bright, firm, and unripe). Natural-origin late-fall chinook salmon encountered during the fall chinook spawning process are culled in order to create timing divergence between fall and late-fall chinook salmon migrations in Battle Creek.

Spring Chinook Salmon

Unmarked fall chinook entering Coleman NFH cannot be reliably differentiated from spring chinook salmon. Late-migrating spring chinook salmon could be blocked by the Coleman NFH barrier weir during the month of September, and collected in the hatchery ponds in October with fall chinook broodstock. Spring chinook collected in the hatchery ponds would be likely culled as excess fall chinook, but they could be inadvertently spawned as fall chinook broodstock at Coleman NFH

The most appropriate method to separate fall and spring chinook salmon at Coleman NFH is to allow access past the Coleman NFH barrier weir into upper Battle Creek throughout the majority of the spring chinook migration (i.e., into September). Information on migration timing of spring chinook salmon in Battle Creek is not currently available. However, spring chinook salmon are known to ascend Mill and Deer Creeks (also east-side tributaries to the upper Sacramento River) primarily between March through June. By allowing spring chinook salmon to ascend Battle Creek past the Coleman barrier weir through the month of August, the probability of encountering spring chinook salmon during broodstock collection at Coleman NFH is greatly reduced.

Claims of past incidences of potential hybridization between fall and spring chinook salmon (1993 and 1995) have been presented by Dr. Dennis Hedgecock of the BML. In those years, approximately 100 random tissue samples were taken from spawned adults throughout the spawn timing to support the generation of baseline genetic information within the basin. Assuming that 10% of the tissues collected came from spring chinook salmon adults, and assuming that they were truly randomly selected from the spawning population, then a population of approximately 8,000 spring chinook salmon were present in Battle Creek in 1995. This population size is inconsistent with estimates generated through monitoring of migrating spring chinook salmon and current expectations of spring chinook salmon run size in Battle Creek.

Steelhead Trout

Steelhead trout broodstock are collected concurrently with fall chinook salmon at Coleman NFH. Steelhead trout encountered during the fall chinook spawning process are either returned to hatchery ponds for holding or released into upper Battle Creek.

Target Population: Late-fall Chinook Salmon

Collection of late-fall chinook salmon at the Coleman NFH on Battle Creek and the Sacramento River at the Keswick Dam fish trap occurs from late November through early March. Federally listed stocks of winter chinook salmon (endangered) and steelhead trout (threatened) co-occur with late-fall chinook salmon in Battle Creek and the Sacramento River, and may be captured while collecting late-fall chinook broodstock. Additionally, natural-origin fall and late-fall chinook (candidate species) which are not targeted for collection on Battle Creek may also be collected from that location.

Identification and disposition of salmonids collected at Coleman NFH during collection of late-fall chinook broodstock are described below:

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Hatchery-origin Fall Chinook Salmon

Differentiation between hatchery-origin fall and hatchery-origin late-fall chinook salmon is accomplished during the initial sorting process based on fin-clip status (adipose) and physical appearance (including coloration, amount of fungus, and degree of ripeness or "firmness"). Since 1995, fall chinook salmon smolts released from Coleman NFH have been marked with an adipose fin-clip and CWT at a rate of approximately 8%. All late-fall chinook originating at the hatchery have been marked (adipose fin-clipped) since 1992. Based on different mark rates, hatchery-origin fall and hatchery-origin late-fall chinook salmon can be differentiated largely on the basis of mark status (presence or absence of an adipose fin).

Physical appearance criteria are used to further differentiate and separate the marked portion (8%) of hatchery-origin fall chinook during hatchery spawning operations for late-fall chinook. For example, broodstock selection criteria during the first few late-fall chinook spawning dates (late-December) select *against* adults that are dark, have excessive fungus, and are overly-ripe. These characteristics indicate the salmon are possibly late-arriving fall chinook. Furthermore, only adipose fin-clipped chinook are spawned during the late-fall spawning season.

Unmarked adults encountered during the late-fall spawning season may be either hatchery-origin fall chinook, or natural-origin fall, late-fall, or winter chinook salmon. All unmarked chinook salmon collected at Coleman NFH during the late-fall chinook spawning season, regardless of phenotypic appearance, will be returned to Battle Creek above the Coleman NFH barrier weir immediately after initial sorting.

While not completely failsafe, run differentiation based on fin-clip status and physical appearance has been effectively used to exclude most non-target, hatchery-origin fall chinook salmon from the late-fall chinook spawning process at Coleman NFH. Effectiveness of these procedures is supported by the fact that no recoveries of coded-wire tagged fall chinook salmon have been made during the late-fall chinook salmon spawning session (USFWS unpublished data from 1991-1998).

Natural-origin Fall, Late-Fall, and Winter Chinook salmon

Unmarked adults encountered during the late-fall spawning season may be either hatchery-origin fall chinook (see above), or natural-origin fall, late-fall, or winter chinook salmon. All unmarked chinook salmon collected at Coleman NFH during the late-fall chinook spawning season, regardless of phenotypic appearance, will be returned to Battle Creek above the Coleman NFH barrier weir immediately after initial sorting.

Steelhead Trout

Steelhead trout broodstock are collected concurrently with late-fall chinook salmon at Coleman NFH. Steelhead trout encountered during the late-fall chinook spawning season are either returned to hatchery ponds for holding or released into upper Battle Creek.

Criteria for distinguishing late-fall chinook salmon from other stocks of salmonids collected at the Keswick fish trap are described below:

Fall Chinook Salmon

Because broodstock collection does not begin at the Keswick fish trap until December, migrating fall chinook salmon are not likely to be collected with late-fall chinook salmon. It is possible that some late-arriving fall chinook salmon could be captured in December. To avoid incorporating these salmon in the late-fall broodstock, any chinook salmon captured in December that is extremely ripe and heavily fungused will be not be transported to Coleman NFH. Instead, the salmon will be relocated to the Sacramento River at Caldwell Park, Redding.

Hatchery-origin Winter Chinook Salmon

Hatchery-origin late-fall chinook salmon are initially distinguished from hatchery-origin winter chinook salmon through phenotypic characteristics. Fin-clipped chinook salmon captured at the Keswick fish trap are sorted based on color, degree of ripeness, size, and amount of fungus. Criteria for identifying late-fall chinook salmon at this time (December through early March) select *for* adults that are dark, ripe, and larger, and have more fungus. Marked chinook salmon phenotypically identified as late-fall run are returned to the upper Sacramento River. Marked chinook salmon phenotypically identified as winter are further distinguished from other stocks of chinook salmon through genetic analyses.

Within three to five days of collecting adults at the Keswick Dam fish trap, tissue samples will be analyzed by Bodega Marine Laboratory and determination of stock will be made based on the results. With results of genetic analysis in hand, quarantined adults will be identified to run by referencing the genetic results with the sequentially-numbered floy tags. Hatchery-origin chinook salmon identified as "non-winter" (possibly late-fall) will then be sacrificed for CWT recovery and verification of the genetic determination.

Natural-origin Winter Chinook Salmon

Natural-origin late-fall chinook salmon are distinguished from natural-origin winter chinook salmon through phenotypic characteristics. Criteria for identifying late-fall from winter chinook salmon select *for* adults that are darker, more ripe, larger, and have more fungus. Periodically, unmarked (presumably natural) chinook salmon captured from the Keswick fish trap that are phenotypically identified as late-fall will be incorporated as Coleman NFH broodstock. During those years, unmarked late-fall chinook salmon will be transported to Coleman NFH and incorporated as broodstock (up to 25% of the total spawning target), or relocated to the upper Sacramento River. Unmarked chinook salmon phenotypically identified as winter will be held at Livingston Stone NFH for genetic analysis. If genetic analyses identify these unmarked salmon as "non-winter," they may be transported to Coleman NFH and incorporated as broodstock for the hatchery's late-fall chinook salmon.

Steelhead Trout

Steelhead trout are inadvertently captured in the Keswick fish trap during collection of late-fall broodstock. Steelhead trout collected from the Sacramento River are returned to the upper Sacramento River.

Hatchery- and Natural-origin Late-fall Chinook Salmon

All hatchery-origin late-fall chinook salmon are mass marked by clipping the adipose fin. Chinook salmon that are phenotypically identified as late-fall run are easily separated into hatchery- and natural-origin stock by mark status. Of fish collected from the Keswick fish trap, unmarked chinook phenotypically identified as late-fall run will be periodically incorporated as broodstock at Coleman NFH. Marked chinook salmon identified as late-fall run and unmarked late-fall chinook salmon not needed as broodstock will be returned to the Sacramento River at Caldwell Park, Redding (RM 299).

Target Population: Winter Chinook Salmon

Hatchery- and natural-origin salmonids from different stocks co-exist with winter chinook in the Sacramento River, and may be collected in the Keswick and RBDD fish traps while collecting winter chinook broodstock. Winter chinook salmon are differentiated from other chinook salmon stocks phenotypically and genetically. This process is similar for the different salmon stocks, so the descriptions for differentiating winter chinook salmon from fall, late-fall, and spring stocks have been combined.

Fall, Late-fall, and Spring Chinook Salmon

Marked and unmarked winter chinook salmon are initially distinguished from other chinook salmon stocks through phenotypic characteristics. Chinook salmon captured at the Keswick and RBDD fish traps are sorted based on color, degree of ripeness (firmness), size, and amount of fungus. When collecting for winter chinook salmon first begins in December, ripe, dark, and fungussed salmon are selected *against*. These are likely to be late-fall chinook, or possibly late-arriving fall chinook salmon. Clean, bright, and firm (unripe) salmon are considered to be winter chinook. In March, April, and May, over-ripe, heavily fungussed salmon are selected *against*. These are likely to be late-fall chinook salmon. Size can also be used to help distinguish between naturally-produced late-fall and winter chinook salmon. Natural-origin late-fall are usually larger than natural-origin winter chinook salmon. In March, April, and May, very clean, bright, and firm salmon are also selected *against*. These fish are likely to be spring chinook salmon. By the end of broodstock collection (late-May through mid-July), selection criteria include dark, ripe, fungussed salmon. Spring and fall chinook are the only other adult salmon in the Sacramento River at that time, and they are usually clean, bright, and firm at this time.

After the initial phenotypic sorting, genetic analyses are completed on each fish identified as a possible winter chinook salmon. Tissue samples are taken, and a color-coded and alphanumeric floy tag is attached to the salmon just below the dorsal fin to allow for individual identification. Tissue samples are sent to BML for genetic analyses within 24 hours. Stock determination from the genetic analyses is usually available 24 to 48 hours after tissue samples arrive at Bodega Marine Laboratory. Computer simulations and "blind tests" show that the genetic discrimination techniques are capable of accurate and consistent identification of winter chinook salmon. Broodstock selection criteria are intended to be conservative, in that some winter chinook salmon may be rejected from the program to guard against potentially including any non-winter chinook salmon in the propagation program. Using past methodology, the probability of wrongly identifying winter chinook salmon (false positives) was less than 0.2% and the probability of

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excluding a winter chinook salmon from the propagation program (false negatives) was less than 6.1%. Recent modifications to the procedure, including analyzing more loci, have further reduced the potential genetic risks of the artificial propagation program, thus protecting the genetic integrity of the naturally-reproducing population the program is designed to supplement. Additional information on the genetic selection criteria for winter chinook salmon is presented in Appendix 6C.

With results of genetic analyses in hand, quarantined adults will be identified to run by cross-referencing the genetic results with the sequentially-numbered floy tags. Hatchery-origin chinook salmon identified as "non-winter" will then be sacrificed for CWT recovery and verification of the genetic results. All hatchery-origin winter chinook salmon are marked with an adipose fin-clip and coded-wire tagged prior to release, so they are easily distinguished from naturally-spawned salmon. Hatchery-origin (adipose fin-clipped) chinook salmon genetically identified as winter chinook will be either: 1) relocated to the mainstem Sacramento River at Caldwell Park in Redding (if not needed for the propagation program); 2) retained for the hatchery propagation program; or, 3) sacrificed for CWT extraction and verification of genetic call. Natural-origin (unmarked) winter chinook salmon are placed into the adult holding tank and retained for the propagation program. Other unmarked chinook genetically determined to be "non-winter" chinook, and any winter chinook in excess to program goals (e.g., over-collection of a single sex) will be relocated to the mainstem Sacramento River at Caldwell Park, Redding. Any unmarked chinook salmon genetically determined to be "non-winter" collected during the adult migration of late-fall chinook may be transported to Coleman NFH and incorporated into the hatchery's late-fall broodstock. Floy tags attached to fish destined for relocation will not be removed, as information potentially gathered during carcass surveys would be valuable in assessing mortality rates of relocated fish.

Steelhead Trout

Steelhead trout are inadvertently captured in the Keswick and RBDD fish traps during collection of winter chinook salmon broodstock. Steelhead trout collected from the fish traps are returned to the Sacramento River at Caldwell Park, Redding.

Target Population: Steelhead Trout

All *O. mykiss* captured at Coleman NFH are considered to be anadromous (steelhead trout). Steelhead trout broodstock is collected from Battle Creek from October through March. Steelhead are easily distinguished from the chinook salmon populations present in Battle Creek, and a discussion of this process is not deemed necessary for this document.

Since brood year 1998, all steelhead trout released from Coleman NFH have been mass-marked by clipping the adipose fin. Consequently, beginning with brood year 2001 hatchery- and natural-origin steelhead trout will be differentiated by assessing mark status.

7.5 Proposed number to be collected

Collection Targets

The Coleman barrier weir effectively blocks upstream passage in Battle Creek. Despite this, some escapement above the barrier weir does occur, especially at flows above 350 cfs. However, the number of salmonids passing unintentionally above the weir is believed to be low. Notwithstanding this low level of unintentional escapement, all salmonids ascending Battle Creek from September 1 through early-March must enter the Coleman NFH. No targets are set for collection of targeted salmonid stocks, but spawning targets are set.

The Keswick Dam is a permanent barrier to migration. No fish are believed to escape above the dam. All salmon and steelhead that attempt to pass the dam are captured by the associated fish trap. Specific collection targets for this location are discussed in the appropriate stock sections (late-fall and winter chinook salmon).

Winter chinook broodstock are only collected from RBDD when sufficient numbers are not collected from Keswick Dam. Only one of the three fish ladders at RBDD has a fish trap, so many of the fish passing RBDD are not captured for broodstock collection. Collection targets for this location are discussed in the section on winter chinook salmon.

Spawning Targets

The Service is examining the feasibility of satisfying production requirements by spawning larger numbers of broodstock and culling excess eggs. This would help maintain genetic fitness of the hatchery stock and allow jacks to be incorporated at rates much closer to actual return rates. When this occurs, spawning targets will increase substantially (approximately double). Spawning broodstock requires considerably more time and personnel than excessing adults. For this reason, it is possible that our ability to incorporate this strategy for fall chinook salmon will be limited by the need to remove excess biomass (i.e., adult chinook) from Battle Creek. We anticipate that this change in spawning operations will be incorporated within the next two to three years. Prior to implementing this change in spawning operations, the Service will submit a protocol to NMFS requesting approval.

Fall Chinook Salmon

Currently, the total spawning target for fall chinook salmon is 5,000 adults (with a 1:1 sex ratio). This number is back-calculated based on a release target of 12 million smolts and estimated fecundity (eggs/female). Refer to Section 1.12 and Table 1-2 for more information.

The number of fall chinook collected at Coleman NFH from 1988 through 1999 is shown in Table 7-1. Males, females, and jacks (fork length < 650 mm) are enumerated separately.

Late-fall Chinook Salmon

Currently, the total spawning target for late-fall chinook salmon is 540 adults (with a 1:1 sex ratio). This number is back-calculated based on a release target of 1 million smolts and estimated fecundity (eggs/female). Refer to Section 1.12 and Table 1-2 for more information. Beginning in brood year 2002, natural-origin late-fall chinook salmon collected from the Keswick fish trap

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will be periodically incorporated into the Coleman NFH broodstock. During years when natural-origin late-fall chinook are included in the hatchery's broodstock, approximately 25% of the broodstock will be natural-origin. Consequently, the collection goal for late-fall chinook salmon at the Keswick fish trap will be 135 natural-origin late-fall chinook salmon.

The number of late-fall chinook salmon collected at Coleman NFH and Keswick Dam from 1988 through 1999 is shown in Table 7-2. Males, females, and jacks (fork length < 650 mm) are enumerated separately.

Table 7-1. Broodstock collection of fall chinook salmon at Coleman National Fish Hatchery, brood years 1988-1999.

Brood Year	**Collected**				**Spawned**			**Eggs**	**Juveniles**
	Females	**Males**	**Jacks**	**Total**	**Females**	**Males**	**Total**		
1988	6,683	7,694	1,175	15,552	5,139	6,565	11,704	25,884,382	22,173,154
1989	4,127	6,052	1,807	11,986	3,237	5,343	8,580	18,096,155	16,897,926
1990	6,405	7,095	1,150	14,650	5,411	5,502	10,913	28,609,707	24,703,022
1991	5,834	4,242	613	10,689	4,692	3,709	8,401	25,187,384	25,342,534
1992	2,970	3,266	1,039	7,275	2,693	2,674	5,367	14,134,423	11,955,288
1993	3,753	3,269	565	7,587	3,487	2,770	6,257	17,979,774	16,702,792
1994	4,308	7,240	7,443	18,991	3,771	4,728	8,499	19,595,404	16,203,694
1995	11,138	13,656	1,883	26,677	3,882	4,277	8,159	21,311,599	19,912,543
1996	8,888	9,935	2,355	21,178	4,264	4,713	8,977	24,556,946	20,433,880
1997	24,467	20,171	6,032	50,670	4,104	4,840	8,944	23,996,644	20,985,660
1998	19,075	23,242	1,804	44,121	3,136	4,440	7,576	15,680,000	13,799,466
1999	10,670	12,377	3,921	26,968	2,297	3,101	5,398	14,280,476	12,260,000

Table 7-2. Broodstock collection of late-fall chinook salmon at Coleman National Fish Hatchery, brood years 1988-2000.

Brood Year	Collection Location	Collected				Spawned			Eggs	Juveniles[a]
		Females	Males	Jacks	Total	Females	Males	Total		
1988	Battle Creek			38	53	186[b]	169[b]	355[b]	1,051,500[b]	24,510
1988	Keswick				411					637,669
1989	Battle Creek	29	24	12	65	22	20	42	96,591	61,105
1989	Keswick	392	423	2	817	318	318	636	1,761,218	847,641
1990	Battle Creek	41	40	11	92	31	30	61	138,087	129,919
1990	Keswick	35	63	2	100	22	43	65	112,208	76,785
1991	Battle Creek	65	81	15	161	60	65	125	217,344	304,171
1991	Keswick	49	65	4	118	45	53	98	235,497	
1992	Battle Creek	164	171	9	344	119	95	214	534,355	340,346
1992	Keswick	239	157	3	399	161	77	238	783,758	
1992	Battle Creek & Keswick	11	10	0	21	11	10	21	57,659	
1993	Battle Creek	187	169	172	528	130	159	289	536,408	760,543
1993	Keswick	168	200	7	375	124	131	255	739,935	
1994	Battle Creek	197	232	169	598	151	145	296	527,914	632,867
1994	Keswick	80	70	4	154	62	48	110	300,423	
1995	Battle Creek	222	225	45	492	162	130	292	730,558	937,784
1995	Keswick	115	99	10	224	97	67	164	527,800	
1996	Battle Creek	541	422	374	1,337	231	164	395	1,082,716	1,086,164
1996	Keswick	29	18	1	48	25	16	41	154,757	
1997	Battle Creek	1,996	2,131	451	4,578	368	414	782	1,615,277	1,154,225
1998	Battle Creek	1,328	1,249	492	3,069	403	359	762	1,845,361	1,245,526
1999	Battle Creek	2,528	3,838	709	7,075	422	542	964	1,366,069	1,124,693
[illegible]	Battle Creek	2,417	1,297	480	4,194	207	277[c]	484	1,093,668	826,444

a Juveniles for brood years 1988-1990 are separated by location of broodstock collection. Records for brood years 1991-1996 do not clearly distinguish broodstock collection locations and listed values are combined totals.

b Includes both Battle Creek and Keswick.

c Includes 22 jacks.

Winter Chinook Salmon

The winter chinook propagation program targets 15% of the estimated run size, with a minimum of 20 and a maximum of 120 winter chinook adults to be retained for any brood year. Therefore, as long as the estimated winter chinook run size is greater than 800, an attempt is made to collect the full allocation of hatchery broodstock. Additionally, the program attempts to secure equal sex ratios of the adults retained.

Winter chinook broodstock collection targets are designed to assure appropriate representation of the complete run timing of winter chinook. A schedule of proposed monthly collection targets for winter chinook broodstock is forecasted prior to the beginning of winter chinook salmon broodstock collection. The pre-season collection schedule is determined by allocating the total annual collection goal (which is determined from the estimated run size) throughout the total duration of historical winter chinook salmon spawn timing. The monthly percentage of the historical run timing is multiplied by the total annual collection goal to get monthly collection goals (Table 7-3). For example, if the estimated run size is 800 the total number of adults targeted for captured would be 800 x 15% = 120. The target number for capture in May is therefore 8.89% x 120 = 11 adults.

The goal is to collect all of the targeted winter chinook salmon from the Keswick fish trap. If it is deemed unlikely that this goal will be met, additional winter chinook salmon will be collected from the fish trap at RBDD. The specific number (and sex) targeted for collection will depend on what is collected at Keswick Dam.

The number of winter chinook salmon collected at Keswick Dam and RBDD from 1989 through 1999 is shown in table 7-4. Males, females, and jacks (fork length < 650 mm) are enumerated separately.

Table 7-3 Monthly collection goals for adult winter chinook salmon based on a run-size estimate of 800, a trapping level of 15%, and the historic percentage of winter chinook salmon passing the Red Bluff Diversion Dam by month. Passage data provided by the California Department of Fish and Game, Red Bluff, California.

Month	Monthly Percentage	Cumulative Percentage	Capture Target
December	1.75	1.75	2
January	5.10	6.85	6
February	9.55	16.40	11
March	35.99	52.39	43
April	28.56	80.95	34
May	8.89	89.84	11
June	6.76	96.60	8
July	3.39	100.00	4
		Total	120

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Table 7-4. Broodstock collection of winter chinook salmon from Keswick Dam and Red Bluff Diversion Dam, brood years 1989-1999. Salmon were propagated at Coleman National Fish Hatchery (1989-1997) or Livingston Stone National Fish Hatchery (1998-1999).

Brood Year	Collection Location	Total Retained	Spawned			Eggs	Juveniles
			Females	Males	Total		
1989	Keswick and RBDD	42	1	1	2	6,191	3,203
1990	Keswick	25	1	1	2	5,012	1,286
1991	Keswick and RBDD	23	6	13	19	29,919	11,582
1992	Keswick	29	13	13	26	59,445	27,404
1993	Keswick and RBDD	20	11	3	14	47,157	19,721
1994	Keswick	29	16	11	27	61,814	44,008
1995	Keswick	47	21	16	37	83,005	50,784
1995	Captive Broodstock	0	21	6	27	31,084	1,131
1996	Captive Broodstock	0	38	30[a]	68	46,292	4,718
1997	Captive Broodstock	0	109	45[b]	154	181,834	31,337
1998	Keswick	106	61	35	96	205,668	155,126
1999	Keswick and RBDD	24	9	14	23	38,303	28,726
1999	Captive Broodstock	0	20	0	20	30,589	4,318

a Includes cryopreserved milt from 12 captive broodstock males.

b Includes cryopreserved milt from 19 captive broodstock males.

Steelhead Trout

Currently, the total spawning target for steelhead trout is 400 adults (with a 1:1 sex ratio). This number is back-calculated based on a release target of 600,000 smolts and estimated fecundity (eggs/female). Refer to Section 1.12 and Table 1-2 for more information. Beginning in brood year 2002, natural-origin steelhead trout collected at Battle Creek will be incorporated into the Coleman NFH broodstock at a rate of approximately 10%. Consequently, the total spawning target will include 40 natural-origin steelhead trout and 360 hatchery-origin steelhead trout.

The number of steelhead trout collected at Coleman NFH from 1988 through 1999 is shown in Table 7-5. Males and females are enumerated separately.

Table 7-5. Broodstock collection of steelhead trout at Coleman National Fish Hatchery, brood years 1988 through 1999.

Brood-year	Returned			Spawned			Eggs	Juveniles
	Females	Males	Total	Females	Males	Total		
1988	546	344	890	222	174	396	958,628	754,830
1989	175	292	467	27	18	45	118,913[a]	44,840
1990	1,905	2,267	4,172	629	463	1,092	2,574,104[b]	1,272,086[c]
1991	661	482	1,143	394	436	830	1,732,341	1,279,449
1992	2,185	2,244	4,429	323	205	528	1,343,039	895,930
1993	652	510	2,862[d]	343	332	675	1,519,175	1,277,430
1994	1,805	1,582	3,387	363	322	685	1,683,653	1,274,149
1995	1,088	949	2,185[e]	311	279	590	1,493,013	1,105,407
1996	1,323	1,324	3,106[f]	231	215	446	1,167,484	939,615
1997	1,342	1,187	2,529	181	186	367	885,046	662,213
1998	738	671	1,409	193	187	380	940,045	546,453
1999	908	847	1,755	164	165	329	739,306	521,232
2000	976	1,000	1,976	183	187	370	878,400[g]	n/a

a An additional 47,000 eggs were received from Feather River State Fish Hatchery. From those, 29,400 smolt were released into Battle Creek.

b Includes 463,573 eyed eggs transferred to Mokelumne State Fish Hatchery.

c Includes 151,470 smolt transferred to Feather River State Fish Hatchery.

d Includes 1,700 that were not sexed

e Includes 148 that were not sexed.

f Includes 459 that were not sexed.

g Estimated number of eggs.

7.6 Disposition of surplus and unripe adults

Hatchery personnel individually assess and sort collected adults as to their final disposition based on phenotypic criteria, current and projected availability of broodstock, and spawning targets. During the sorting process, unripe and surplus chinook salmon and steelhead trout are separated from adults to be used as broodstock. Non-target fishes are also identified and separated from broodstock. Following the initial sorting process, collected adults may be either spawned, culled (excessed), released, or returned to the hatchery ponds for holding.

Fall Chinook Salmon

Disposition of Surplus Adults

Surplus fall chinook adults (in excess of daily egg-take goals) collected in the hatchery ponds are either culled or returned to the hatchery ponds for holding until a future spawning event. Disposition of unspawned fall chinook salmon depends on the date of capture, availability of replacement broodstock, physical condition, and maturation status of collected fish. During recent years, large numbers of fall chinook salmon have been culled at Coleman NFH because of large returns to Battle Creek and the availability of replacement broodstock (Table 7-6). To alleviate some of the chinook salmon biomass in lower Battle Creek, the Coleman NFH has initiated a culling program, hereafter referred to as "excessing," whereby adults are collected at the hatchery and killed without spawning. From 1995 through 1999, an average of over 96,000 fall chinook salmon were estimated returning to Battle Creek, greatly exceeding broodstock requirements at Coleman NFH and availability of natural spawning habitats. During 1997, 1998, and 1999, an average of nearly 31,500 fall chinook salmon were excessed during fall chinook spawning operations (Table 7-6).

Table 7-6. Estimated return of fall chinook salmon to Battle Creek, return to Coleman National Fish Hatchery (NFH) and number excessed at Coleman NFH.

Brood Year	Estimated Return to Battle Creek[a]	Return to Coleman NFH	Number Excessed
1991	17,241	10,683	1,340
1992	12,708	7,275	853
1993	18,616	7,587	422
1994	43,265	18,991	9,016
1995	83,192	26,677	15,074
1996	73,582	21,178	9,448
1997	101,413	50,670	39,570
1998	98,308	44,351	34,876
1999	119,919	26,970	18,713
2000	75,106	21,659	14,313

a Estimated run-size was generated by the California Department of Fish and Game.

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Prior to 1994, excessed fish were usually early arriving males, jacks, or poor quality females. Between 1994 and 1999, no deliberate method was in place for selecting fish to be culled, with the exception of selection for jacks. Jacks have been incorporated as broodstock, but at low levels and not at the rate of return. Beginning in brood year 2000, jacks have been incorporated as broodstock at a rate of approximately 5%. While this is usually lower than rates of return, a 5% incorporation rate ensures that some jacks are used as broodstock. The Service is examining the feasibility of satisfying production requirements by spawning larger numbers of broodstock and culling excess eggs. This would allow jacks to be incorporated at rates much closer to actual return rates, and will also help maintain genetic fitness of the hatchery stock.

Disposition of Unripe Adults

Unripe fall chinook salmon encountered during the initial fall chinook sorting process may be either excessed or returned to the hatchery holding ponds for ripening, depending on the time of capture and the abundance of replacement broodstock. For example, unripe fall chinook salmon collected at the beginning of the fall chinook spawning season are excessed because replacement broodstock are readily available. Late in the fall chinook spawning season (early- to mid-November), collections of fall chinook broodstock, especially males, may become scarce[2]. At that time, unripe males may be returned to the hatchery holding ponds for spawning at a later date.

Late-fall Chinook Salmon

Disposition of Surplus Adults

Surplus collections (in excess of daily egg take goals) of hatchery-origin late-fall chinook salmon at Coleman NFH are either returned to the hatchery ponds for holding until the next scheduled spawn date or excessed, depending on the availability of replacement broodstock. During recent years, surplus collections of hatchery-origin late-fall chinook salmon have been excessed because the number of adults collected have greatly exceeded broodstock requirements at the hatchery.

Disposition of Unripe Adults

Unripe hatchery-origin late-fall chinook salmon collected at Coleman NFH will be separated from ripe spawners during the initial sorting process. At that time, unripe adults may be either excessed or returned to the hatchery holding ponds for ripening, depending on the abundance of replacement broodstock. For example, unripe late-fall chinook salmon collected at Coleman NFH at the beginning of the spawning season are generally returned to the hatchery ponds for holding because the actual run size is unknown at that time. At the end of the late-fall chinook spawning season, unripe broodstock encountered during the initial sort may be excessed if replacement broodstock are readily available in excess of broodstock requirements.

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[2] Adult fall chinook salmon are generally available in substantial numbers in lower Battle Creek through late-November, however, fall chinook broodstock collections at the hatchery generally decrease dramatically in early-November. This apparently results from the onset of natural pairing, redd construction, and spawning - leading to a decreased propensity for upstream migration.

Unripe natural-origin late-fall chinook captured at the Keswick Dam fish trap will be transported to the adult holding ponds at Coleman National Fish Hatchery where they will be held until ripe. Excess natural-origin late-fall chinook will not be collected from the Sacramento River or culled at the hatchery.

Winter Chinook Salmon

Disposition of Surplus Adults

Monthly trapping efforts for winter chinook salmon are frequently adjusted to stay within target collection rates. This adjusting maintains the capture rate within the set limit (15% of the estimated run size). Additionally, as trapping efficiency at the Keswick Dam fish trap is somewhat dependant on the actual population size, a pre-season overestimate of the run-size is not likely to result in an excess take level. The maximum collection level (15%) has not been exceeded for the last 11 years (Table 7-7).

Table 7-7. Rates of winter chinook salmon captured for spawning at Coleman (1989-1995) and Livingston Stone (1998-2000) National Fish Hatcheries.

Year	Estimated Run-Size[a]	Adults Captured	Percent of Run Captured	Adults Retained	Percent of Run Retained
1989	533	42	8	42	8
1990	441	25	6	25	6
1991	191	23	12	23	12
1992	1180	69	6	29	2
1993	341	24	7	20	6
1994	189	29	15	29	15
1995	1361	190[b]	14	47	3
1996	1296	No adults collected, moratorium on broodstock collection			
1997	841	No adults collected, moratorium on broodstock collection			
1998	2612	121	5	102	4
1999	3208	25	1	24	1
2000	1350	113	8	88	7

a Estimated run-size was generated by the California Department of Fish and Game.

b Majority of these fish were collected on 6/27 and 6/28/95.

Steelhead Trout

Disposition of Surplus and Unripe Adults

Surplus collections of steelhead trout at Coleman NFH (in excess of daily egg-take goals) may be returned to the hatchery ponds for holding, released into upper Battle Creek to spawn naturally, or sacrificed for recovery of coded-wire tags. Early in the collection season, nearly all steelhead trout encountered at the hatchery are very green (firm, bright, and unfungussed) and are returned to the hatchery ponds for holding. After a sufficient number of steelhead have been retained such that it can be reasonably assured that hatchery spawning targets will be met, surplus collected (hatchery- and natural-origin) steelhead trout are metered into upper Battle Creek. The goal of providing regulated passage into upper Battle Creek is twofold: 1) to assure that hatchery steelhead trout broodstock requirements are met; and, 2) to initiate recovery of a natural spawning population in Battle Creek. Prior to release, all steelhead collected at Coleman NFH are passed through a tunnel-type CWT detector (Northwest Marine Technology, Inc. Shaw Island, WA) to identify tagged steelhead. All tagged steelhead will be sacrificed for CWT recovery.

7.7 Health maintenance and sanitation procedures applied

Fall and Late-fall Chinook Salmon and Steelhead Trout

At Coleman NFH, the number of adults entering the adult collection and holding ponds is monitored to prevent overcrowding and minimize pre-spawn mortality. To do this, an electronic counter is located at the pond entrance. A picket weir is inserted into the fish ladder when the maximum number of adults permitted to enter the pond is reached. This prevents additional fish from entering the holding ponds. The maximum number of adults allowed into the collecting ponds is usually 2,000 to 2,500. In the event that conditions in the hatchery ponds become unfavorable for holding adult salmonids (e.g., warm or turbid water), fewer fish may be allowed to enter the ponds.

In addition, steelhead broodstock are separated from chinook salmon prior to extended holding at the hatchery. Separation between the species occurs at the time of initial sort, and minimizes injury and mortality of steelhead resulting from larger-bodied chinook salmon. Additionally, steelhead trout are held at an appropriate density to avoid overcrowding.

Several sanitary practices are also in effect to minimize the chance of introducing or spreading pathogens. Equipment used in the spawning building is routinely disinfected with iodophor and outer clothing (e.g., rain gear and rubber boots) worn in the spawning building may not be used for other hatchery activities. This helps prevent transmission of pathogens from one area to another.

Winter Chinook Salmon

Various drugs and therapeutic and prophylactic treatments are used on winter chinook salmon broodstock at Livingston Stone NFH to increase survival of adults, reduce risks of disease transmission to offspring, and to aid in synchronous maturation (Table 7-8). Additionally,

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anaesthetics and artificial slime are used to reduce stress on broodstock. The applications of most drugs used at Livingston Stone NFH follow the Food and Drug Administration's (FDA) Investigational New Animal Drug procedure. Fish health is monitored closely by hatchery personnel and staff from the Service's CA-NV FHC.

Table 7-8. Drugs and treatments applied to maintain health of winter chinook broodstock at Livingston Stone National Fish Hatchery. The following listing should not be considered all-inclusive as other drugs and treatments may be used as necessary and as recommended.

Type	Dosage	Method	Application
oxytetracycline	20 mg/kg	IP injection	antibacterial
erythromycin	20 mg/kg	dorsal sinus injection	antibacterial
erythromycin		oral	antibacterial
iodophor	75 ppm	bath	antibacterial
malachite green	1 ppm	bath	antifungal
formalin	167 ppm	flow through	antifungal
MS-222		bath	anaesthetic
Luteinizing hormone Releasing hormone analog (LH-RHa)	30 µg/kg solution or 30 µg/kg implant	IP injection	induce maturation
Vibrio spp. vaccine		bath	vaccination against salt-water *Vibrio* spp.
salt		bath/flow through	stress reducer
artificial slime	1 qt/1,200 gallons	bath/flow through	stress reducer

7.8 Disposition of carcasses

Fall and Late-fall Chinook Salmon and Steelhead Trout

Carcasses of hatchery-spawned, overly-ripe, or injured chinook salmon are rendered by a local company. Fresh and unspawned (excessed) carcasses collected at the hatchery are donated to the Federal Bureau of Prisons or the Bureau of Indian Affairs through a contract with a commercial seafood processor.

Sacrificed and spawned carcasses of female steelhead trout are also rendered. Spawned males are released above the barrier weir in Battle Creek to contribute to the natural population of steelhead trout in upper Battle Creek.

Winter Chinook Salmon

Carcasses of winter chinook salmon cannot be rendered or donated because they are treated with chemicals. Instead, they must be disposed of in a landfill.

7.9 Risk aversion measures to minimize the likelihood for adverse genetic or ecological effects on naturally-produced salmonids

Fall Chinook Salmon

Genetic and ecological risks to the natural population of fall chinook salmon in Battle Creek are minimized through a variety of risk aversion measures. Fall chinook salmon in Battle Creek are managed as an integrated population of mixed hatchery- and natural-origin. The majority of fall chinook salmon entering Battle Creek are considered to be hatchery-origin, and naturally spawning fall chinook salmon in Battle Creek are presumed to originate primarily from Coleman NFH ancestry. Broodstock collection targets for fall chinook broodstock at Coleman NFH include both hatchery- and natural-origin adults. By incorporating natural-origin adults, genetic and ecological differences (and therefore risks) between hatchery and natural populations are minimized (see Appendix 6D for a more thorough discussion of genetic risks to natural populations from hatchery propagation). Genetic risks of hybridization between different runs are minimized by selecting broodstock based on phenotypic characteristics and mark status (see Section 7.4). Genetic and ecological risks from founder effects and artificial selection are minimized by: 1) collecting and spawning broodstock across the natural run and spawn timing, and 2) spawning large numbers of broodstock (~ 5,000).

During recent years, considerable natural spawning by fall chinook salmon has occurred in Battle Creek, primarily below the Coleman NFH barrier weir. The offspring of these naturally spawning adults, as well as strays of naturally spawning fall chinook salmon from the Sacramento River, may return to Battle Creek and be obstructed by the Coleman NFH barrier weir. Natural-origin fall chinook salmon blocked from upper Battle Creek by the barrier weir may attempt passage over the barrier weir, remain in lower Battle Creek to spawn naturally, volunteer into the Coleman NFH collection ponds, or return to the Sacramento River to spawn naturally. Delays in migration are usually short because fish that enter the hatchery are usually sorted within three days (range 1-7 days). Stress from handling and collection is minimized by preventing crowding (limiting the number of fish allowed in the collecting ponds) and using anaesthetics to decrease handling time and stress on the fish. Excess fall chinook salmon are not released above the barrier weir to minimize the risk of hybridization with endangered spring chinook salmon.

Late-fall Chinook Salmon

Similar to fall chinook salmon, genetic and ecological risks to the natural population of late-fall chinook salmon are minimized in a variety of ways, including: 1) integrating natural-origin adults as hatchery broodstock (see Appendix 6D for a more complete discussion of genetic risks to natural populations from hatchery propagation efforts), 2) spawning relatively large numbers of adults as broodstock (~ 540) to minimize risk of genetic drift and founder effects, and 3) collecting and spawning adults across the entire range of their run/spawn timing.

Risks to natural late-fall chinook associated with broodstock collection and congregation activities are minimized through a variety of management practices. Late-fall chinook salmon arrive at Battle Creek primarily during December and January (Figure 7-5). Nearly all late-fall chinook salmon entering Battle Creek are the result of hatchery production. Only hatchery-origin late-fall chinook collected at Battle Creek (as indicated by an adipose fin-clip) are used as broodstock at Coleman NFH, so unmarked chinook salmon collected during the late-fall spawning season are released into Battle Creek above the barrier weir. Migration delays of natural-origin late-fall chinook salmon which enter the collection ponds are short (<7 days, usually 1-3 days) because of frequent sorting events. Stress from handling and collection is minimized by preventing crowding (limiting the number of fish allowed in the collecting ponds) and using anaesthetics to decrease handling time and stress on the fish.

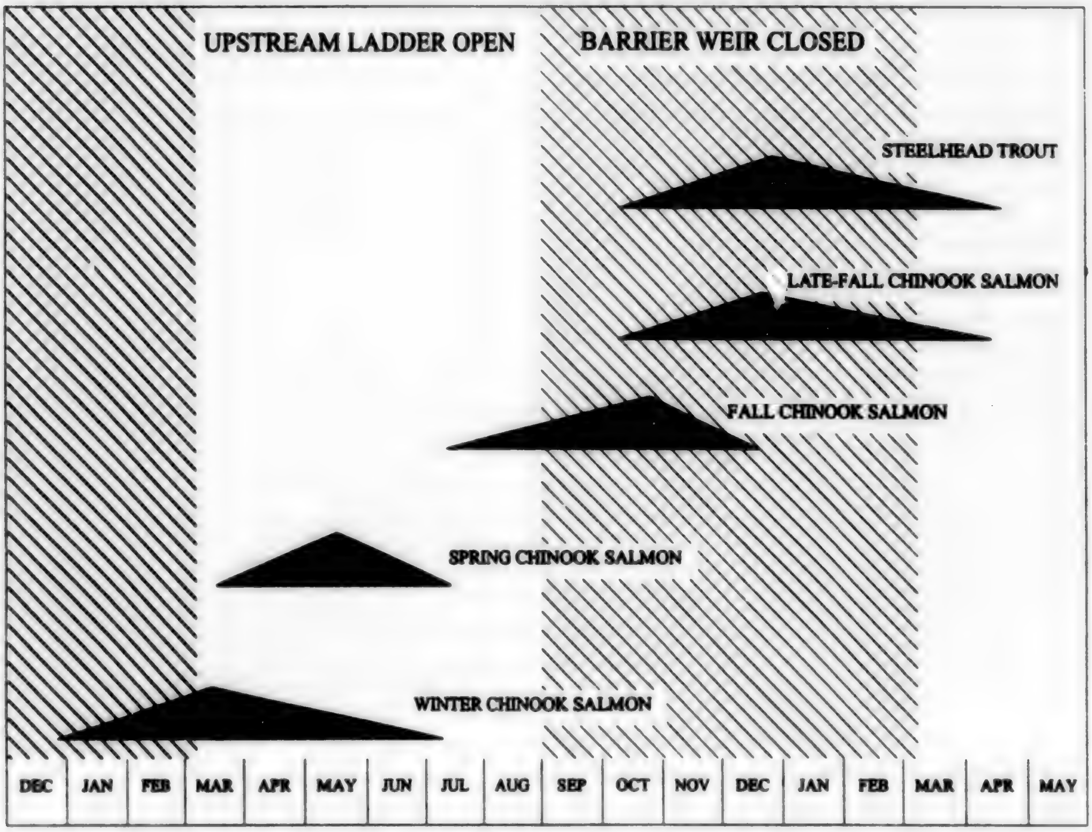

Figure 7-5. Approximate timing for salmonid migration in Battle Creek and operation of Coleman barrier weir at Coleman National Fish Hatchery, California. Peaks correspond to peaks in migration, and spread indicates range of migration timing. Area does not indicate the proportion of the run passing. Adapted from Vogel and Marine (1991) and U.S. Fish and Wildlife Service (unpublished data). winter chinook (unmarked) are returned to Battle Creek above the barrier weir.

During years when natural-origin late-fall chinook salmon are incorporated as broodstock at Coleman NFH, they will be collected from the Keswick Dam fish trap. Salmon phenotypically identified as late-fall chinook will be transported to Coleman NFH (up to 135 adults). Salmon that are originally identified as phenotypically winter but are not genetically identified as winter may also be transferred to Coleman NFH if they are collected during the late-fall migration timing. Risks associated with transport and handling are minimized by using salt, artificial slime, ice, and anaesthetics as necessary, and an aerated, insulated, transport tank.

Negative effects to the naturally spawning population of late-fall chinook in the Sacramento River are not likely to occur as a result of hatchery broodstock collections. Straying by hatchery-origin late-fall chinook from Coleman NFH is more than sufficient to offset the periodic collection of 135 natural-origin adults. An estimated 10% of returning hatchery-origin late-fall chinook stray from Battle Creek. During recent years, returns of late-fall chinook salmon to Coleman NFH have ranged from 3,069 (1998) to 7,075 (1999). Applying a stray rate of 10%, we estimate that 307 and 708 hatchery-origin late-fall chinook strayed from Coleman NFH during 1998 and 1999. The majority of strays likely return to the upper Sacrament River and spawn naturally with natural-origin late-fall chinook salmon.

Winter Chinook Salmon
The majority of migrating adult winter chinook salmon is allowed to pass the barrier weir through its upstream fish ladder (Figure 7-5). A small proportion (approximately 15%) of early-arriving winter chinook salmon are blocked at the Coleman NFH's barrier weir from late December through early March, during late-fall chinook broodstock collection. While the upstream fish ladder is closed and broodstocks are congregated, winter chinook salmon reaching Coleman NFH may attempt passage over the barrier weir, remain in lower Battle Creek to spawn naturally, volunteer into the Coleman NFH collection ponds, or return to the Sacramento River to spawn naturally. Fish that enter the hatchery are usually sorted within three days (range 1-7 days) and any unmarked chinook salmon collected during late-fall chinook spawning (late December through February) are returned to Battle Creek above the barrier weir. Consequently, migration delays are thought to be minimal. Stress from handling and collection is minimized by preventing crowding (limiting the number of fish allowed in the holding ponds) and using anaesthetics to decrease handling time and stress on the fish. Any hatchery-origin (marked) chinook returning during this time period that phenotypically appear to be winter run will be sacrificed for coded-wire tag recovery.

The purpose of the winter chinook propagation program at Livingston Stone NFH is to assist in the recovery of the natural population. Considerable effort has been made to minimize any adverse genetic or ecological effects on the natural population. The proportion of hatchery-origin winter chinook included as broodstock is limited to 10% to minimize hatchery selection effects. In addition, upper (no more than 15% of estimated run-size) and lower (at least 20 fish) limits have been set for natural-origin winter chinook collected as broodstock. The lower limit helps to ensure genetic variability while the upper limit protects the naturally spawning population.

Spring Chinook Salmon
Genetic and ecological risks to spring chinook salmon populations are minimized through several risk aversion measures. First, the fish ladder around the barrier weir at Coleman NFH is left open to upstream migration from early March through August 31. Therefore, for the majority of the adult migration of spring chinook, fish are allowed to pass the barrier weir and enter upper Battle Creek (Figure 7-5). A small portion of the adult spring chinook migration may be blocked when broodstock collection begins in September. Spring chinook salmon blocked from upper Battle Creek by the barrier weir may attempt passage over the barrier weir, remain in lower Battle Creek to spawn naturally, volunteer into the Coleman NFH collection ponds, or return to the Sacramento River to spawn naturally. In addition, excess fall chinook salmon are not released above the Coleman barrier weir to minimize the risk of hybridization with spring chinook salmon. It has also been suggested that hybridization between natural-origin spring and hatchery-origin fall chinook has occurred during hatchery spawning operations. The Service believes this to be unlikely based on analysis of information presented in Banks et al. 2000 (see complete discussion in Section 6.8).

Risks of delayed migration at the mainstem Sacramento River are decreased by minimizing the time any one salmon is delayed. Phenotypically identified spring chinook salmon captured from the Sacramento River at RBDD are released above the dam (RBDD) that day. Any spring chinook salmon that were mistakenly classified as phenotypically winter at RBDD would be delayed. This delay in migration is short (usually 1-3 days) because genetic analyses to separate winter chinook from other runs are usually completed within 48 hours. Any spring chinook salmon would then be returned to the Sacramento River at Bend Bridge (RM 258). This location is near suitable spawning habitat and also affords these salmon an opportunity to enter Battle Creek. Risks associated with transport and handling are minimized by using salt, artificial slime, ice, and anaesthetics as necessary, and an aerated, insulated, transport tank.

Salmonids captured at Keswick Dam are transported and sorted at Livingston Stone. Phenotypically identified spring chinook salmon are returned to the Sacramento River at Bend Bridge (RM 258). Any spring chinook salmon phenotypically identified as possible winter chinook are handled in the same manner as those collected from RBDD (described above). Stress associated with transport and handling is limited in the same manner as that described for fish transported from RBDD.

Steelhead Trout
Similar to fall and late-fall chinook salmon, genetic and ecological risks to the natural population of steelhead trout are minimized in a variety of ways, including: 1) integrating natural-origin adults as hatchery broodstock (see Appendix 6D for a more complete discussion of genetic risks to natural populations from hatchery propagation efforts), 2) spawning relatively large numbers of adults as broodstock (~ 400) to minimize risk of genetic drift and founder effects, and 3) collecting and spawning adults across the range of their run/spawn timing.

Steelhead trout migrate into Battle Creek from October through March, with the majority of fish entering Coleman NFH between November and January (Figure 7-5). Steelhead trout entering Battle Creek are considered to be of mixed-origin, representing the progeny of hatchery production at Coleman NFH and natural production in Battle Creek. Natural steelhead production in upper Battle Creek results from escapement above the barrier weir and regulated passage of steelhead adults passing through Coleman NFH. The offspring of these naturally spawning steelhead, as well as strays of naturally spawning salmon in the Sacramento River or associated tributaries, may return to Battle Creek and be obstructed by the barrier weir. Estimates of natural-origin steelhead trout were not available prior to 2000 because all hatchery-origin steelhead were not marked prior to brood year 1998.

Negative effects to the natural population of steelhead trout in Battle Creek are not likely to occur as a result of collections for hatchery broodstock. Steelhead trout blocked from upper Battle Creek by the barrier weir may attempt passage over the barrier weir, remain in lower Battle Creek to spawn naturally, volunteer into the Coleman NFH collection ponds, or return to the Sacramento River to spawn naturally. Fish that enter the hatchery are usually sorted within three days (range 1-7 days). Steelhead are separated from chinook salmon to minimize the likelihood of steelhead incurring injuries from the larger salmon. Stress from handling and collection is minimized by preventing crowding (limiting the number of fish allowed in the collecting ponds) and using anaesthetics to decrease handling time and stress on the fish. Only 10% of the hatchery's broodstock are expected to be natural-origin steelhead (n = 40). Any natural-origin steelhead collected in excess will be returned to Battle Creek above the barrier weir. In addition, excess hatchery-origin steelhead and spawned males (both hatchery- and natural-origin) will also be passed above the barrier weir to assist in the recovery of Battle Creek steelhead trout.

7.10 Annual take levels for ESA-listed fish resulting from broodstock congregation and collection at Coleman and Livingston Stone NFH's.

Congregation and collection of broodstock from Battle Creek and the Sacramento River (at fish traps at RBDD and the Keswick Dam) may negatively affect natural ESA-listed populations of winter and spring chinook salmon and steelhead trout. Take may occur as collection, handle, transport, tissue sample, and intentional or unintentional lethal take. Additionally, listed and unlisted salmonids may be blocked from accessing spawning and rearing habitats in Battle Creek. Battle Creek above the Coleman barrier weir includes designated critical habitat for steelhead trout (63 FR 7764; February 16, 2000) and restorable, high-quality habitats for winter and spring chinook salmon. Following are summaries of risks and estimates of take associated with broodstock congregation and collection.

Battle Creek

Passage at the Coleman barrier weir is blocked from September 1 through early-March. During that time period, target stocks of fall and late-fall chinook and steelhead trout will be congregated and collected as hatchery broodstock. Non-target stocks of ESA-listed winter and spring chinook salmon may also be blocked by the barrier weir or collected at Coleman NFH.

Winter Chinook Salmon

Winter chinook salmon migrations in the upper Sacramento River extend from mid-December through mid-July, with a migration peak in March. Based on sampling conducted at RBDD, 16.5% of returning adults migrate past RBDD by March 1. Winter chinook migration in Battle Creek occurs primarily from March through July. Based on recent winter chinook run estimates for Battle Creek (liberally estimated at 100) and migration timing at RBDD, up to 17 winter chinook salmon could be obstructed from upper Battle Creek by a closed fish ladder at the Coleman barrier weir.

Incidental take of winter chinook salmon may occur as migration delay, blockage, capture, handling, or unintentional mortality. Early-arriving winter chinook salmon migrating in Battle Creek prior to early-March would likely be diverted into the hatchery's adult collection ponds during the late-fall chinook spawning season. Natural-origin winter chinook salmon collected in the hatchery ponds will be unmarked. Unmarked chinook salmon will be sorted from hatchery-origin (marked) late-fall chinook salmon during the initial sorting process and promptly released into Battle Creek above the barrier weir. Holding of adults in the hatchery ponds prior to the initial sorting process generally lasts from one to three days, but may be as long as seven days. Winter chinook collected during the late-fall spawning season are generally in good physical condition (bright, firm, and non-fungussed) so mortality is not expected to occur (<1%) while in the hatchery.

Spring Chinook Salmon

Historic records of spring chinook migration timing indicate arrival in the upper Sacramento River and tributaries from mid-March through the end of July, with the peak of migration in late-May and early-June. Current migration timing of Cental Valley spring chinook is believed occur later than historic accounts, extending from mid-March through mid-October, with a peak of migration about September 1 (CDFG 1998). However, this apparent shift in migration timing may be representative of spring chinook in Butte Creek and the Feather River, but does not appear typical of the migration patterns observed in Mill and Deer Creeks, tributaries of the upper Sacramento River (Colleen Harvey, CDFG, Red Bluff, CA , pers. com.). In those tributaries, spring chinook migration typically begins in March, peaks during May, and ends in early-July.

Spring chinook migration into Battle Creek is believed to follow a similar temporal distribution to Mill and Deer Creeks (Figure 7-6). Monitoring at the Coleman barrier weir during 2000 showed adult chinook salmon migrating from early-March (when the weir was opened) until mid-July. From mid-July to mid-August, no chinook salmon passed the barrier weir. Adult chinook salmon re-appeared at the weir in mid-August. Chinook salmon observed passing the barrier weir between August 13 and September 1include two marked (adipose fin clipped) fish out of 29 total (plus 1 "unknown" mark status) for a 7% mark rate, indicative of fall chinook salmon originating at Coleman NFH. Closing the barrier weir on September 1 prohibits early-arriving fall chinook from accessing spring chinook spawning areas in upper Battle Creek.

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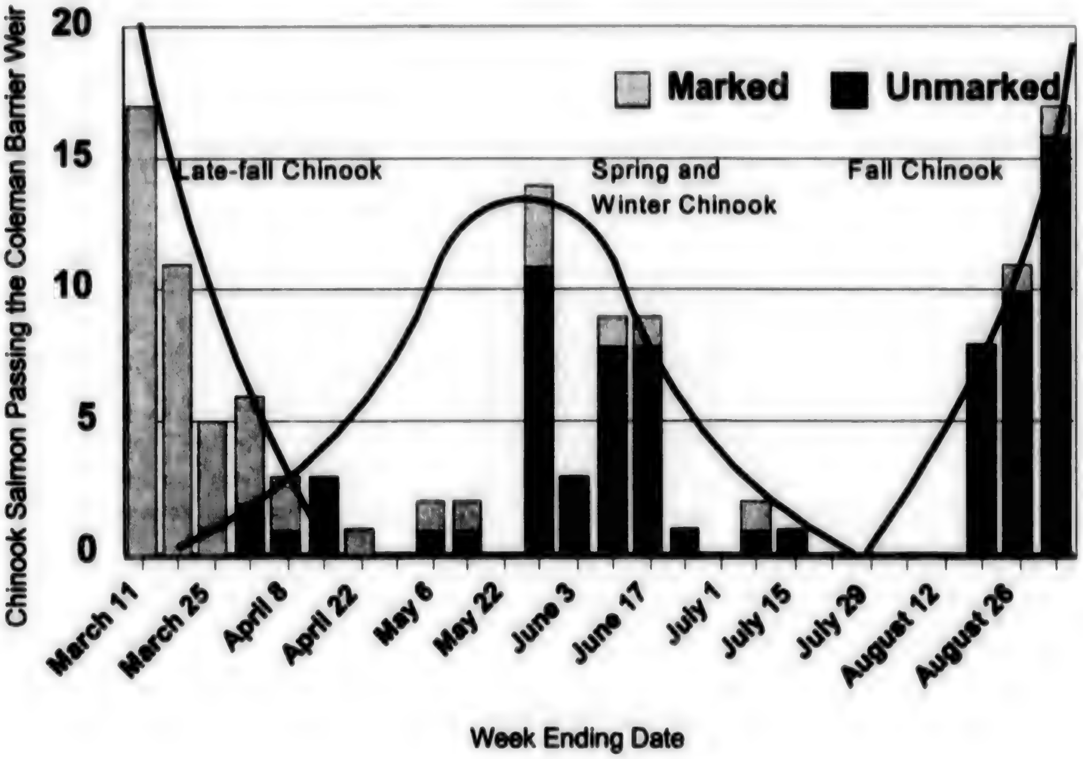

Figure 7-6. Chinook salmon passage at the Coleman barrier weir from March 7 to September 1, 2000. Also shown are probable run composition of three discrete migration periods.

Based on the preceding information, we believe that it is unlikely that spring chinook salmon will be blocked at the Coleman barrier weir or collected at Coleman NFH. Spring chinook salmon migration in the upper Sacramento River begins in mid-March, after the fish ladder is opened at the Coleman barrier weir. The spring chinook migration into Battle Creek likely ends in July when water temperatures in the lower section of the creek become unfavorable for survival. While spring chinook migration is known to extend into October or November for other tributaries to the lower Sacramento River, the migration timing observed in Battle Creek is probably similar to that observed in Mill and Deer Creeks. This makes biological sense considering that, for over 100 years, chinook adults have been confined to lower Battle Creek by September 1.

Spring chinook salmon migrating in Battle Creek from early-March through September 1 will be able to ascend the fish ladder at the Coleman barrier weir. Passage may be temporarily delayed while they locate the ladder entrance. However, locating and passing through the open fish ladder is not believed to pose a problem of extended delays to migration.

A few early- and late-arriving spring chinook could be delayed or blocked by the Coleman NFH barrier weir. Spring chinook migrating prior to early-March would likely enter into the hatchery where they would be identified as natural-origin by mark status (unclipped ad-fin) and immediately released above the barrier weir in Battle Creek. Delay resulting from collection in the hatchery ponds is short (<7 days, usually 1-3 days). If late-migrating spring chinook were blocked at the barrier weir after the upstream fish ladder was closed on September 1, those fish would be blocked at the weir and possibly collected in the hatchery ponds. Spring chinook entering the hatchery at that time would likely be characterized as fall chinook salmon due to the inability to distinguish fall and spring chinook salmon based on phenotypic characteristics.

Access into upper Battle Creek by fall chinook salmon is restricted beginning September 1 by closing the upstream fish ladder on the Coleman barrier. The barrier weir is closed primarily to congregate fall chinook broodstock. However, closure of the upstream fish ladder at the Coleman barrier weir on September 1 may be warranted regardless of the need to congregate and collect hatchery broodstock. Closure of the barrier weir on September 1 helps maintain spatial and temporal separation between fall and spring chinook in upper Battle Creek. Fall chinook salmon which ascend Battle Creek migrate into spawning habitats used by spring chinook salmon. If the upstream ladder were left open after September 1 there would be a high likelihood of redd superimposition and hybridization between fall and spring chinook salmon in upper Battle Creek.

During the period 1986 to 1989, fall chinook were intentionally passed above the Coleman barrier weir to spawn naturally in upper Battle Creek. During an aerial survey of Battle Creek in 1986 fall chinook salmon were observed in the Wildcat, Coleman, and Inskip reaches (Dave Hoopaugh, retired CDFG, as cited through Kier Associates 2000). More recently, snorkle surveys conducted in upper Battle Creek from 1997 through 1999 have shown that chinook salmon abundance in the Wildcat and Eagle Canyon reaches also increase when fall chinook begin to congregate (and escape past) the Coleman barrier weir (unpublished data, USFWS, Red Bluff, CA). These sections are considered high quality habitat for spring chinook salmon. The effects of future dam removals associated with the Battle Creek restoration process on maintaining spatial and temporal separation between fall and spring chinook salmon in Battle Creek is unknown.

Steelhead Trout
Scant information is available to estimate the magnitude of the natural steelhead trout run returning to Battle Creek. Prior to brood year 2001, hatchery- and natural-origin steelhead trout collected at Coleman NFH were not differentiable. Juvenile steelhead trout produced at Coleman NFH have been completely (100%) marked since brood year 1998. Beginning with brood year 2001, nearly all hatchery-origin steelhead trout will be identifiable based on mark status (adipose fin-clip).

Future returns of natural-origin steelhead to Battle Creek will likely increase compared to the recent past. Increased returns of natural origin-adults are expected to result from spawning by hatchery-origin steelhead passed above the Coleman barrier weir. Over 1,000 adult steelhead have been released from Coleman NFH above the barrier weir each year for the last three years (1,163 in 1999, 1,416 in 2000, and 1,483 in 2001). Assuming an one to one replacement ratio of adult spawners, we estimate up to 1,500 natural-origin steelhead trout returning to Battle Creek in the near future.

Nearly the entire migration timing of steelhead trout in Battle Creek occurs during periods when the upstream fish ladder at the Coleman barrier weir is closed (Figure 7-5). Natural-origin (unmarked) steelhead trout are present in Battle Creek during the congregation and collection of hatchery broodstock for fall and late-fall chinook salmon and steelhead trout. Take of steelhead trout at Coleman NFH may occur as capture, handle, removal as broodstock, unintentional lethal take, or blockage from critical habitats in upper Battle Creek.

Steelhead trout at Coleman NFH are integrated with the natural population in Battle Creek. Natural-origin steelhead trout are targeted for collection and incorporation as hatchery broodstock at a rate of 10% each year. Hatchery- and natural-origin steelhead collected at Coleman NFH will be held until a time such that it appears likely that hatchery broodstock targets will be met. Thereafter, hatchery- and natural-origin steelhead trout in excess of broodstock requirements will be passed above the barrier weir to spawn naturally in upper Battle Creek. During recent years, substantial numbers of hatchery-origin steelhead have been passed above Coleman NFH to establish a naturally-spawning population in upper Battle Creek.

Natural-origin steelhead trout that are not incorporated as hatchery broodstock will be separated during the initial sorting process at Coleman NFH. Initial sorting generally occurs within two to three days, but may be up to seven days after entering the hatchery ponds. Steelhead trout typically enter the hatchery in good physical condition and mortality of steelhead trout prior to initial sorting is uncommon. Handling procedures used during the sorting process are designed to minimize the potential of injury to steelhead trout (e.g., using anaesthetics during handling and separating steelhead from larger chinook). Overall mortality of steelhead trout collected at the hatchery and released into Battle Creek is expected to be low (<1%).

Estimated take of ESA-listed salmonids resulting from broodstock congregation and collection in Battle Creek are shown in Table 7-9.

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Table 7-9. Estimated take of ESA-listed salmonids resulting from broodstock congregation and collection in Battle Creek.

	Species / Run		
Type of Take	Winter Chinook	Spring Chinook	Steelhead Trout
Delay at weir[a]	83	100	0
Capture, hold, handle, and release[b]	17	0	1,450
Spawning as broodstock	0	0	50
Unintentional lethal take[c] (<1%)	1	1	15

a Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.

b Take occurring due to collections at the hatchery prior to upstream release

c Unintentional mortality of listed fish, including loss of fish during holding prior to spawning or prior to release into the wild.

Keswick and RBDD Fish Traps

Keswick Fish Trap - Collections of late-fall and winter chinook broodstock begin at the Keswick fish trap in mid-December. Broodstock collections at the Keswick fish trap continue through February for late-fall chinook and into July for winter chinook. Spring chinook salmon and steelhead trout co-exist in the upper Sacramento River with late-fall and winter chinook salmon, and may be incidentally collected in the Keswick fish trap along with the target stocks. Take of these ESA-listed species may occur as capture, handle, transport, tissue sample, and intentional or unintentional lethal take. All fishes captured at the Keswick fish trap are transported to the Livingston Stone NFH where they are sorted Non-target fishes are separated and released near suitable spawning habitats in Redding.

Anadromous (i.e., steelhead) and non-anadromous (rainbow trout) *O. mykiss* are incidentally collected at the Keswick fish trap while trapping for late-fall and winter chinook salmon. Most *O. mykiss* collected are presumed to be non-anadromous; however, the anadromous and non-anadromous life history types are not differentiable based on physical appearance. For that reason, both life history forms are considered together in this document as steelhead.

Steelhead are captured frequently while collecting winter chinook broodstock at the Keswick fish trap. During collections of winter chinook broodstock in 1999, 64 steelhead were inadvertently collected. Steelhead collected at the Keswick fish trap are sorted at Livingston Stone NFH and returned to the Sacramento River. Total time in captivity is approximately two to four hours. Mortality is not expected to occur as a result of this activity.

Future operations of the Keswick fish trap will begin earlier to capture late-fall as well as winter chinook broodstock. Information is not available to reliably estimate future take of steelhead trout occurring during the extended timing of broodstock collections at Livingston

Stone NFH. However, based on a preliminary trapping effort conducted during 1999, late-fall chinook salmon are expected to readily volunteer into the Keswick fish trap. If this cursory effort is indicative of future efforts, this suggests that broodstock collections for late-fall chinook salmon will be accomplished quickly, thus reducing incidental collections of steelhead trout. We estimate that as many as 250 steelhead trout may have been incidentally collected at the Keswick fish trap while collecting winter chinook broodstock during recent years. However, due to recent modifications to the Keswick fish trap (improved "fish-tightness") and extended trapping efforts to collect late-fall chinook salmon, we estimate that as many as 1,000 steelhead trout may be incidentally collected (Table 7-10). All steelhead trout collected at the Keswick fish trap will be released into the Sacramento River at Caldwell Park (RM 299), near suitable spawning habitats. Unintentional mortality occurring as a result of capture, transport, and release is expected to be less than two percent (n-20, Table 7-10).

Spring chinook salmon migrate into the upper Sacramento River during March when winter chinook broodstock are being collected at the Keswick fish trap. Chinook salmon collected at the Keswick fish trap are assessed for run identity based on phenotypic characteristics. Phenotypically identified spring chinook salmon are tissue sampled and released into near suitable spawning habitats in Redding. These fish may spend two to four hours in captivity before they are released. Chinook salmon phenotypically identified as winter are tissue sampled and placed in quarantine until genetic run is determined. Genetic analysis may require three to five days. All genetically identified non-winter chinook are transported to the Sacramento River at Redding where they are released. Mortality occurring as a result of capture, transport, and holding is expected to be less than 1% (Table 7-10).

Data from previous trapping activities for winter chinook salmon can be used to provide an indicator of future incidental take of spring chinook salmon at the Keswick fish trap. During collection of winter chinook broodstock for brood year 2000, 73 of 155 chinook salmon were returned to the Sacramento River based on phenotypic or genotypic assessment of run indicating non-winter chinook salmon (USFWS, RBFWO, unpublished data). During 1999 trapping operations at the Keswick fish trap 17 of 42 salmon handled were identified as non-winter chinook salmon (USFWS, RBFWO, unpublished data). Most non-winter chinook collected during 2000 were considered to be spring chinook salmon. One genetically identified non-winter chinook died while in holding.

Based on information from 1999 and 2000, we anticipate that approximately half of the adult chinook salmon collected while trapping for winter chinook broodstock will be incidentally captured spring chinook salmon. Anticipating that winter chinook collection targets will be 120 naturally produced adults during future years, we can expect to capture, hold (possibly), and release up to 150 spring chinook salmon annually (Table 7-10). Since spring chinook salmon are generally in good health when encountered during collection of winter chinook broodstock, unintentional mortality of spring chinook is not expected to exceed four percent. We do not expect incidental take of spring chinook salmon to increase due to the collection of late-fall chinook at the Keswick fish trap because the timing of adult migrations for late-fall and spring chinook do not overlap appreciably.

RBDD Fish Trap - The fish trap in the east fish ladder of RBDD is operated by the CDFG to estimate salmon abundance. This activity is covered for ESA section 7 compliance by the CDFG. The fish trap at RBDD may also be used to collect adults for the winter chinook propagation program. Collection of hatchery broodstock at RBDD is a back-up measure implemented when collections at the Keswick trap are not adequate to collect the full spawning target for winter chinook. Winter chinook broodstock are typically collected at RBDD only during the end of the spawning season (e.g., July), and only for a small number of adults.

Winter chinook adults are initially selected at RBDD based on phenotypic characteristics. Past performance shows a high level of accuracy in phenotypically identifying winter chinook salmon at RBDD. Phenotypic winter chinook salmon are transported to Livingston Stone NFH, and samples of fin tissue are taken for genetic analysis. Genetic analysis is usually completed within three to five days. Depending on collection needs, genetically identified winter chinook may be incorporated as winter chinook broodstock or released into the Sacramento River near suitable spawning habitats in Redding. Genetically identified non-winter chinook salmon collected from RBDD are likely to be spring chinook salmon based on similar phenotype and overlapping migration timing. These salmon are relocated to the Sacramento River at Bend Bridge (RM 258), affording them an opportunity to ascend Battle Creek (or other tributaries upstream) or to remain in the Sacramento River. Take of spring chinook salmon could occur as capture, transfer, holding, and unintentional mortality (Table 7-10). Mortality of spring chinook occurring as a result of capture, transport, and holding is not expected (≤1).

Because of the small numbers of adults collected and at RBDD and the accuracy demonstrated at identifying target broodstock, we estimate future take of spring chinook salmon will be low (≤5). All genetically identified non-winter chinook will be released into the Sacramento River at Bend Bridge (RM 258), affording them an opportunity to ascend Battle Creek (or other tributaries upstream) or to remain in the Sacramento River.

Table 7-10. Estimated incidental take of ESA-listed salmonids resulting from broodstock collection at Keswick Dam (subscript K) and Red Bluff Diversion Dam (subscript R) fish traps.

	Species	
Type of Take	Spring Chinook	Steelhead Trout[a]
Capture, handle, transport and release[b]	$0_K / 0_R$	$1{,}000_K / 0_R$
Capture, handle, transport, tissue sample, hold, and release[c]	$150_K / 5_R$	$0_K / 0_R$
Unintentional lethal take[d]	$6_K / 1_R$	$20_K / 0_R$

a Includes both anadromous steelhead and non-anadromous rainbow trout.

b Take occurring due to collections of non-target fish at the Keswick trap prior to release into the Sacramento River

c Take resulting from mis-identification of winter chinook salmon, quarantine during genetic analysis, and release into the Sacramento River, Redding.

d Unintentional mortality of listed fish, including loss of fish during holding prior to spawning or prior to release into the wild.

MATING

Mating strategies for winter chinook salmon are not discussed in this document, but this information has been discussed in a previous ESA section 10 permit application (USFWS 1996).

8.1 Selection method

Fall and Late-fall Chinook Salmon

Broodstock selection for fall and late-fall chinook salmon occurs randomly from the total number of ripe salmon over 650 mm FL collected in the hatchery ponds. Jacks (salmon less than 650 mm FL) are incorporated at approximately 5% for each spawning event. Males and females are paired (1:1) randomly to maintain genetic variability and fitness of the hatchery stocks, and to minimize artificial selection that could lead to genetic divergence from naturally reproducing stocks.

Steelhead Trout

Since 1990, broodstock selection for steelhead trout has occurred randomly from the total number of ripe adults longer than 554 mm FL (longs) collected in the hatchery ponds. Steelhead trout less than 554 mm (shorts) have been selected *against* as broodstock at Coleman NFH based on evidence which suggested they may represent remnants of hybridized crossings with a non-anadromous strain of rainbow trout previously propagated at the hatchery. At that time, it was the belief of many fish culturists that a stock of ocean-going steelhead trout could be developed by excluding non-anadromous trout from hatchery spawning, thereby breeding-out characteristics of non-anadromy. Recent analysis of steelhead trout otoliths contradicts the previous finding that most steelhead trout shorts are non-anadromous. Further, recent research suggests different polymorphisms of the Oncorhynchus mykiss species interbreed naturally. Based on this new information, the size-based broodstock selection criterion are being modified, beginning with BY 2002, to incorporate the full size distribution of collected adults. (see Section 8.3 on back-up, precocious, and repeat spawners).

8.2 Spawn timing

Fall and late-fall chinook salmon, and steelhead trout are spawned throughout the duration of natural spawn timing. Spawning of fall chinook salmon begins in mid-October and extends through mid-November. Spawning of late-fall chinook and steelhead trout begins in late-December and continues until about March 1. Appendix 8A shows spawn timing for fall and late fall chinook salmon at the Battle Creek Station and Coleman NFH from 1909 through 1998. Appendices 8B and 8C show previous spawn timing at Coleman NFH for winter chinook salmon and steelhead trout, respectively.

Spawning Schedules

Hatchery spawning schedules, including spawn dates and number of broodstock to be spawned, are determined prior to the onset of each spawning. Spawning schedules at Coleman NFH are designed to mimic the hypothetical bell-shaped distribution of natural spawning populations. For example, the number of fish spawned at the tails of the spawning distribution (beginning and end of the run) are generally smaller and the egg-takes are less frequent as compared to the middle (mode) of the spawning distribution when egg-takes are generally larger and spawning events occur more frequently (Fig. 8-1).

The number of female broodstock to be spawned is determined by dividing the total egg collection target (see Section 9.1) by the estimated fecundity of hatchery broodstock. Fecundity estimates for fall and late-fall chinook salmon are based on long-term averages of number of eggs per female. Periodic fecundity estimates are conducted using egg counts from females collected for broodstock to compare present fecundity with long-term averages. Based on information collected during within season fecundity counts, the spawning schedule may be adjusted as needed to meet production targets and avoid over-production. Fall chinook salmon average 5,400 eggs per female. Based on a total egg collection target of 14,029,000, the estimated number of female spawners is 2,600 fall chinook salmon. Late-fall chinook salmon average 4,500 eggs per female. Based on a total egg collection target of 1,247,000, the estimated number of female spawners is 280.

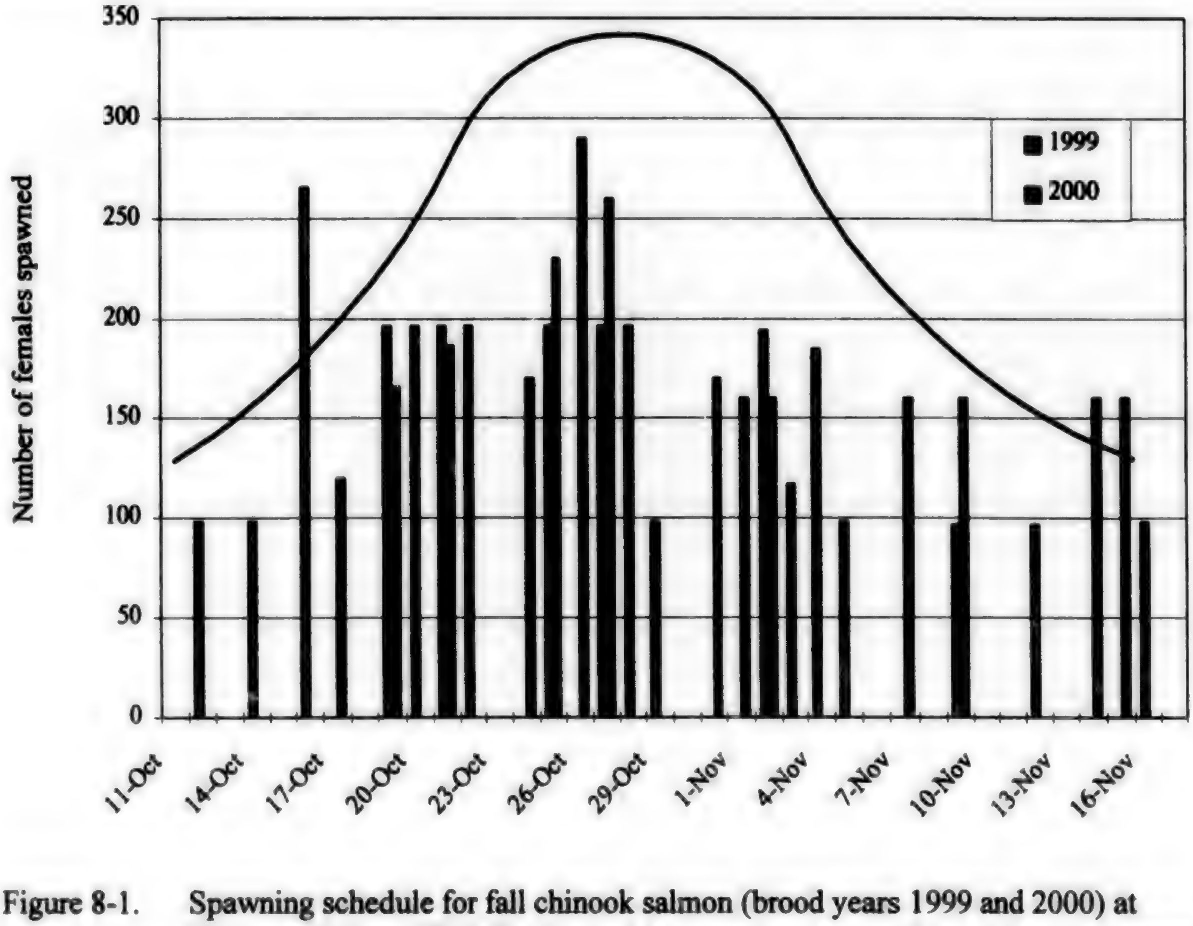

Figure 8-1. Spawning schedule for fall chinook salmon (brood years 1999 and 2000) at Coleman National Fish Hatchery. An approximate normal curve is superimposed.

Another consideration when determining spawning schedules is facilitating fish culture in the hatchery environment. The number of eggs taken for any spawning event are determined such that resulting fry and smolts can be readily transferred to rearing units with similarly-sized fish. This is accomplished, in general, by sizing egg takes such that final pond loadings will combine fish from egg-takes no more than one or two weeks apart. Accounting for on-station mortality, fall chinook salmon are usually spawned in increments of about 93 females as this will yield the final ponding target of 428,600 smolts per 15-foot x 150-foot raceway. Similarly, late-fall chinook salmon are spawned in increments of about 21 females as this yields the final ponding target of 75,000 smolts per 15-foot x 150-foot raceway.

8.3 Backup, precocious, and repeat spawners

Fall and Late-fall Chinook Salmon

Prior to brood year 2000 (fall) and brood year 2001 (late-fall), jacks were incorporated at some small but unknown percent. Beginning with spawning of fall chinook broodstock in October 2000, jacks (FL < 650 mm) were incorporated as broodstock at a rate of approximately 5% of the number spawned per spawning day. This strategy of incorporating jacks at a flat-rate fo 5% was chosen to ensure that jacks will be used as hatchery broodstock. Actual return rates for jacks among chinook salmon populations are usually less than 10% (Godfrey 1968 *in* Healey 1991).

At the end of the spawning season, some fall and late-fall chinook salmon may be retained for possible spawning at a later date (back-ups). Holding salmon helps to ensure an adequate number of broodstock is available to meet egg-take goals at the end of the season when replacement broodstock may be difficult to collect in the hatchery ponds.

Steelhead Trout

Scale analysis of Coleman NFH steelhead broodstock conducted during the late-1980's suggested that 92% of returns greater than 540 mm FL were anadromous steelhead trout, whereas 76% of fish less than 540 mm FL were non-anadromous. Based on this information, the Service began breeding only individuals longer than 554 mm FL in 1990 to "breed-out" characteristics of non-anadromous rainbow trout.

Through analysis of otolith microchemistry, the Service has recently re-examined the practice of excluding shorter steelhead trout from broodstock at Coleman NFH. Analysis of otolith microchemistry is a relatively recent development in fishery science, and is based on the fact that fish incorporate certain elements found in the surrounding water into the mineral structure of their otoliths. Concentration of the element strontium varies in direct proportion to the salinity of water (Dietrich et al.1980), thus, otoliths of anadromous fishes show a transition from relatively low levels of strontium to higher levels of strontium. Non-anadromous fishes do not show this strontium pattern in their otolith structure. Strontium distribution patterns from steelhead trout collected at Coleman NFH showed that the majority of returning fish, regardless of size, are anadromous (USFWS, unpublished data).

With new evidence of anadromy for shorter steelhead returning to Coleman NFH, an investigation was initiated in brood year 1999 to evaluate the offspring of shorter steelhead trout in regards to survival, health, growth, physiology (smoltification), and life-history characteristics. Another objective of this evaluation is to determine modifications required to culture offspring of shorter steelhead (which may show decreased growth or survival as compared to longer steelhead trout) at Coleman NFH. This investigation, which continues through brood year 2001, involves spawning steelhead trout from the entire size distribution of returning adults. Results of this investigation will be used to determine preferred culture rates and methods at Coleman NFH for spawning steelhead throughout the entire size spectrum of returning adults. Currently, the only steelhead shorts used as broodstock are incorporated in the investigation outlined above. We anticipate that at some later date the Service will incorporate steelhead shorts as a standard spawning practice at Coleman NFH.

Steelhead trout arrive at Coleman NFH before they are fully mature, so they are held (banked) until spawning. Banking of steelhead is described in more detail in section 7, page 7-10 (broodstock collection). Female steelhead are killed during the hatchery spawning process so repeat hatchery-spawning by females is not possible. Steelhead males are released after spawning to contribute to natural spawning in Battle Creek following their release. Based on previous studies, hatchery-spawned males are not expected to survive and contribute to spawning during successive years. An investigation conducted at Coleman NFH during 1970 to 1971 showed repeat spawners comprised only 1.1% of the returning adult population (Hallock 1989), and repeat spawning by males is considered to be a very unusual.

8.4 Fertilization

Fall and Late-fall Chinook Salmon

Hatchery spawning of fall and late-fall chinook salmon is conducted with equal sex ratios and a 1:1 mating scheme. Infrequently, gametes from more than a single male may be used to fertilize the eggs of an individual female if either the gametes of the first male encountered are suspected to be of poor quality, or if the quantity of ripe males is limited. Following fertilization, eggs are placed into an iodophor disinfecting solution. Eggs are then transferred to the incubation building where they are placed into Heath Trays for incubation.

Steelhead Trout

Spawning protocol for steelhead trout is generally similar to that of chinook salmon, using equal sex ratios and a 1:1 mating scheme. The primary difference between chinook salmon and steelhead trout spawning protocols is that male steelhead trout broodstock are not destroyed during the spawning process. Instead, ripe male steelhead trout are anaesthetized with carbon dioxide, partially stripped of their gametes, and released into upper Battle Creek to contribute to natural spawning.

8.5 Cryopreserved gametes

Coleman NFH has not used cryopreserved gametes for spawning of fall or late-fall chinook salmon or steelhead trout.

8.6 Proposed changes to current spawning operations at Coleman NFH

In addition to the recent modifications of the steelhead mating strategy, the Service is also considering several additional changes to spawning protocols at Coleman NFH. Alternative spawning protocols under consideration include: 1) increasing the number of broodstock spawned and culling excess eggs (in addition to culling only adults), 2) lengthening fall chinook spawning operations to encompass November and early December, and 3) culling additional adult fall chinook to decrease biomass in lower Battle Creek. A brief discussion of each alternative spawning strategy is presented below. Prior to implementing any of these changes in spawning operations, the Service will submit a protocol to NMFS requesting approval.

Alternative 1: The Service is currently examining the feasibility of modifying spawning operations at Coleman NFH by spawning larger numbers of adults and culling excess eggs. A similar spawning strategy is currently used at several State-operated hatcheries in the Central Valley. This strategy is in contrast to current spawning protocols for fall and late-fall chinook and steelhead trout at Coleman NFH wherein *all* of the eggs from spawned females are used to meet hatchery production targets. Spawning increased numbers of adults would help to maintain within-population genetic diversity and reduce the potentially deleterious effects of inbreeding. The overall goals of this strategy are to minimize the potential for genetic differences between the hatchery and natural stocks, which could reduce the fitness and viability of natural populations. We anticipate this change in spawning protocol will be made within the next two to three years. When this new spawning strategy is implemented at Coleman NFH, spawning targets will increase substantially (perhaps double). However, because the process of spawning adults requires considerably more time and personnel than culling adults, it is possible that our ability to incorporate this strategy for fall chinook salmon will be limited by the need to remove excess biomass (i.e., adult chinook) from Battle Creek.

Alternative 2: The Service is considering lengthening fall chinook spawning operations to encompass November and early December. During recent years, chinook salmon adults returning between fall and late-fall spawning have been culled to promote separation in spawn timing and minimize the potential for hybridization between late-arriving fall chinook and early-arriving late-fall chinook. The appropriateness of continuing this practice is questionable, however, because: 1) fall and late-fall chinook populations in Battle Creek can be partly differentiated based on mark status (e.g., adipose fin) and phenotypic condition; and, 2) culling of adults between the fall and late-fall spawning seasons results in directional selection against late-arriving adults. Extending fall chinook spawning into early December will help to avoid intentional run-timing selection and maintain natural patterns of genetic variation for other traits genetically correlated with run timing.

Alternative 3: The Service will investigate the potential drawbacks and benefits of culling additional adult fall chinook to decrease biomass in lower Battle Creek. Concerns about effects of excess hatchery returns of fall chinook adults on naturally-produced juveniles in Battle Creek include: 1) increased stress on juvenile salmonids emigrating past large numbers of adults congregated for broodstock collection, 2) increased risks of disease transmission to naturally

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produced juveniles from large numbers of IHNV-infected adults, and 3) decreased natural production in lower Battle Creek caused by redd superimposition or reductions in available oxygen associated with decaying carcasses. While evidence for these concerns is lacking, the Service will continue to investigate these concerns and will consider culling additional fall chinook adults to minimize potential impacts to natural populations. Since broodstock spawning operations require more time and personnel than culling operations, incorporating more adults as broodstock may need to be balanced with the desire to decrease adult fall chinook biomass in Battle Creek.

INCUBATION AND REARING

Information presented in this section describes current and anticipated incubation and rearing practices at Colman NFH, which are subject to modification. Actual incubation and rearing practices used at Coleman NFH may differ from the information presented in this section because of improvements to fish culture techniques or unforseen circumstances (e.g., disease, unusually low or high rate of growth). All artificial propagation practices used at Coleman NFH, including incubation and rearing, are managed adaptively, with the goals of producing high quality fish that maximize opportunity to accomplish program goals and minimizing potential negative impacts to natural stocks.

Some information on winter chinook salmon is presented in this section. More complete data on winter chinook can be found in USFWS (1996) and will be presented in greater detail in a future ESA Section 10 enhancement permit application.

9.1 Incubation

Egg Collection

Fall and Late-fall Chinook Salmon and Steelhead Trout

Annual egg collection targets for fall and late-fall chinook and steelhead trout at Coleman NFH are determined by back-calculating from the release targets, accounting for anticipated levels of mortality during the different life/rearing stages at Coleman NFH. Total egg collection for late-fall chinook is determined prior to the beginning of the spawning season by adding-in the expected losses of eggs and juveniles resulting from mortality occurring during the major life/rearing stages at the hatchery. Survival rates by life stage, total egg take targets, and release targets are given in Table 9-1.

Historically, the numbers of eggs actually collected from chinook salmon and steelhead trout varied greatly. Five-year averages (and standard deviations) from 1995 through 1999 are: 20,009,000 (± 4,690,000) for fall chinook salmon; 1,328,000 (± 438,000) for late-fall chinook salmon; and, 1,045,000 (± 294,000) for steelhead trout.

Winter Chinook Salmon

Annual egg collection targets for winter chinook salmon at Livingston Stone NFH are based on the number of broodstock collected. Survival rates by life stage are given in Table 9-1. The number of eggs collected from winter chinook salmon have also varied greatly, depending on the number of broodstock collected.

Table 9-1. Survival estimates, total egg take targets and release targets for salmonid stocks propagated at Coleman and Livingston Stone National Fish Hatcheries. Estimates are based on historical data (U.S. Fish and Wildlife Service, unpublished data).

	Survival Rate					
Broodstock	**Green egg to eyed egg**	**Eyed egg to ponding**	**Ponding to release**	**Over-all egg to release**	**Total egg take target**	**Release target**
Coleman						
Fall Chinook	0.90	0.99	0.97	0.86	14,029,000	12,000,000
Late-fall Chinook	0.89	0.99	0.89	0.82	1,247,000	1,000,000
Steelhead Trout	0.90	0.99	0.85	0.77	783,024	600,000
Livingston Stone						
Winter Chinook[a]	0.89	0.86	0.88	0.69	depends on number of broodstock	≤250,000

a Survival rates are based on a two year average (1998 and 1999) that does not include captive broodstock crosses.

Surplus Egg Takes

Fall and Late-fall Chinook Salmon and Steelhead Trout

Spawning schedules for fall and late-fall chinook and steelhead at Coleman NFH have been recently restructured to reduce the likelihood that eggs or juveniles will need to be culled at Coleman NFH. Spawning schedules for fall and late-fall chinook and steelhead have been designed to accomplish production targets, accounting for anticipated levels of mortality during incubation and rearing. Within-season fecundity counts are conducted to verify pre-season estimates of fecundity and minimize the likelihood of over or under collection. Excess eggs are not collected to buffer for unforseen levels of mortality. In the event of unforseen mortality, the number of juveniles released will be less than the production target. As a result of the restructured spawning schedules at Coleman NFH, culling of excess production should not be required. In the unlikely event that culling of chinook salmon or steelhead is necessary at Coleman NFH, hatchery production will be culled at the earliest possible stage of development, and not-later than the eyed-egg stage.

Winter Chinook Salmon

Winter chinook salmon are reared in a manner which promotes maximum survival of the resulting offspring. No culling is performed on winter chinook salmon eggs or juveniles.

Loading Densities

Fall and Late-fall Chinook Salmon and Steelhead Trout

Incubation units consist of sixteen-tray vertical fiberglass incubators (Heath Incubation Trays). The top tray of each incubation stack is not used to limit the exposure of incubating eggs to light and silt. Loading densities are approximately 8,500 eggs per tray for fall chinook salmon and 4,500 eggs per tray for late-fall chinook salmon. Steelhead trout eggs are incubated at approximately 9,700 eggs per incubation tray[1].

Winter Chinook Salmon

Incubation units at for winter chinook salmon are similar to those used for fall and late-fall chinook and steelhead trout. Loading densities[2] of winter chinook salmon vary, usually ranging between 1,700 and 3,000 eggs per tray. These densities are lower than those used for other hatchery stocks of chinook salmon because each female is mated with two males, and each mating combination is kept separate during incubation. In other words, each male-female mating (called a family group) is incubated separately.

Fish Health Maintenance and Monitoring

Fish culture operations at Coleman and Livingston Stone NFH's are designed to produce healthy juveniles (smolts or pre-smolts). Sanitary conditions are maintained during fish incubation by disinfecting (with iodophor at approximately 500ppm for 1 minute) all equipment between uses with different egg lots. Eggs surfaces are disinfected with iodophor during spawning, eggs are water hardened with an iodophor solution (100 ppm for 15 minutes), and they are also periodically treated with formalin washes as a prophylactic treatment for fungus while in the incubation trays. After eye-up, non-viable eggs are separated and removed from healthy eggs in the incubation trays.

9.2 Rearing

Survival Rates

Survival rates of chinook salmon and steelhead trout stocks vary depending on life stage and stock (Table 9-1). Fall chinook salmon generally have the highest survival rates at all life stages reared in the hatchery. Steelhead trout and winter chinook salmon tend to have the lowest survival rates.

Density and Loading Criteria

Fall Chinook Salmon

After the fall chinook fry are buttoned up and swimming well, they are taken out of the incubation trays in the hatchery and placed into outside rearing units. Until recently, they have been stocked into 8-foot x 80-foot (small) raceways first, at loadings of approximately 300,000 - 500,000 fish per unit. Flows of 300 - 450 gpm are maintained through each raceway. After the fry have reached a total weight of approximately 550 lbs. (approx. 3.75 mm) in the 8-foot x 80-foot raceways, they were transferred to the 15-foot x 150-foot (large) raceways at a final loading of approximately 500,000 per raceway. Flows in these larger raceways are approximately 600 - 800 gpm.

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[1] Use of incubation jars for steelhead trout is currently being evaluated at Coleman NFH.

[2] Loading densities refer to numbers of individuals per containment unit. 'Individuals' may be eggs, fry, or other life history stages.

Initial loading density indices[3] average 0.17 for the small raceways and 0.13 for the large raceways (Table 9-2). Final loading density indices are 0.32 and 0.25 for the small and large raceways, respectively. Final rearing density varies, but usually is around 0.5 lbs/ft^3.

Table 9-2. Density indices, final densities, and final fork lengths for three stocks of salmonids propagated at Coleman National Fish Hatchery. Data are five-year averages from 1995 through 1999 (U.S. Fish and Wildlife Service, unpublished data).

Broodstock	Type of rearing unit (feet x feet)	Density index[a] Initial (SD)	Density index[a] Final (SD)	Final density lbs/ft^3	Final fork length mm (in)
Fall Chinook Salmon	8 x 80 raceway	0.1718 (0.0314)	0.3244 (0.0774)	0.55	43 (1.70)
	15 x 150 raceway	0.1319 (0.0379)	0.2527 (0.0646)	0.43	46 (1.79)
	split 15 x 150 raceway[b]	0.1160 (0.0255)	0.2463 (0.0440)	0.67	75 (2.95)
Late-fall Chinook Salmon[c,d]	indoor tanks (16 x 3.25)	0.1817 (0.0399)	0.3020 (0.1089)	0.58	49 (1.92)
	8 x 80 raceway (from tanks)	0.0701 (0.0052)	0.0601 (0.0020)[e]	0.25	105 (4.10)
	8 x 80 raceway (from incubation trays)	0.1253 (0.0310)	0.1896 (0.0485)	0.50	66 (2.60)
	15 x 150 raceway	0.0668 (0.0230)	0.1274 (0.0304)	0.67	134 (5.28)
Steelhead Trout	indoor tanks	0.1288 (0.0329)	0.3065 (0.0846)	0.51	43 (1.68)
	8 x 80 raceway	0.1110 (0.0540)	0.1369 (0.0534)	0.46	86 (3.37)
	15 x 150 raceway	0.0411 (0.0138)	0.1547 (0.0198)	1.35	195 (7.68)

a Density indices are calculated using the following equation: DI = W/(FL*V), where DI = density index, W = weight of fish in rearing unit, FL = average fork length (in), and V = volume (ft3) of rearing unit.

b Fall chinook salmon are split once after initial loading into 15-foot x 150-foot raceways. These data are from after that split.

c Some late-fall chinook salmon were transferred to the indoor tanks after leaving incubation, others were transferred directly to the 8-foot x 80-foot raceways.

d Some late-fall chinook salmon are raised to final stocking size in 8-foot x 80-foot raceways to accommodate experimental designs. Parameters associated with experimental groups are not presented in this table.

e Reduction in final density index is probably caused by additional splitting associated with accommodation of experimental groups.

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[3] Density indices are based on the proportion of the fish length used in determining the pounds of fish to be held per cubic foot of rearing space. The Service uses 0.3 for chinook and steelhead raised at Coleman NFH (Wedemeyer and Wood 1974 in Piper et al. 1982).

During recent years, experimental trials have been conducted to evaluate the efficacy of ponding fall chinook salmon directly into the large raceways at final loadings. This modification to the fall chinook ponding strategy is being conducted to decrease handling of fish and the associated stress. For brood year 2000, approximately ⅔ of total fall chinook production were transferred directly from the incubator stacks into the large raceways at final loading numbers.

Late-fall Chinook Salmon

In the past, late-fall chinook salmon have been transferred from incubation trays to fiberglass early-rearing tanks located in the hatchery building or to the small raceways outdoors. Recent hatchery protocol is to transfer late-fall chinook fry directly into the small raceways. Late-fall chinook salmon are transferred to large raceways at approximately 66 mm, where they reach their final stocking size of approximately 130 mm (Table 9-2). Final pond loading densities for the large raceways are approximately 75,000 smolts per raceway. Transfers to final ponding densities are completed during mid-August to mid-September. The initial loading density index for small raceways averages 0.18; final loading density index averages 0.19 (Table 9-2). Initial loading density index for large raceways averages 0.07, and final loading densities average 0.13. Flows for small and large raceways are similar to those used for fall chinook salmon.

Late-fall chinook salmon are frequently used for experimental releases (e.g., they have been used as surrogates for spring chinook smolts in delta studies). Rearing of salmon raised for experimental purposes may vary, depending on the experimental design.

Steelhead Trout

After hatching, fry are transferred into fiberglass early-rearing tanks located in the hatchery building. Flows of about 30 gpm are maintained through each tank. At a size of about 500/lb (approx. June 1), steelhead fry are moved outside to the small raceways where they rear to approximately 86 mm (Table 9-2). Steelhead trout are transferred when densities in the small raceways reach approximately 0.5 lbs/ft^3. The initial loading density index for small raceways averages 0.11; final loading density index averages 0.14 (Table 9-2). Initial loading density index for large raceways averages 0.04, and final loading density index averages 0.15. In the past, juvenile steelhead trout were graded and transferred into either the large raceways (larger grade-outs) or the pre-release pond (smaller grades). Currently, juvenile steelhead are not graded before moving to large raceways or the pre-release pond. In brood year 2001, a sub-sample of juvenile steelhead trout will be placed in the pre-release pond as part of a natural rearing experiment.

Feeding and Food Conversion

Fall and late-fall chinook salmon and steelhead trout are fed a ration based on percent body weight per day. Food types and conversion efficiencies are presented in Table 9-3. In general, conversion rates for younger fish tend to be better than conversion rates for older fish. Conversion rates vary among stocks, but it is difficult to interpret this variation because age varies as well.

Table 9-3. Food type and conversion efficiencies for two rearing ages of chinook salmon and steelhead trout. Stocks are propagated at Coleman National Fish Hatchery. Conversion efficiencies are based on five-year averages from 1995 through 1999 (U.S. Fish and Wildlife Service, unpublished data).

Stock	Approximate age from spawning (days)	Food type (pellet)	Conversion efficiency (lbs of feed/ lbs of fish)
Fall Chinook Salmon	119	Semi-moist	1.06
	178	Semi-moist	1.03
Late-fall Chinook Salmon	185	Semi-moist	1.31
	308	Semi-moist	1.31
Steelhead Trout	161	Semi-moist	1.02
	284	Dry	1.31

Fish Health Maintenance and Monitoring
Fish culture operations at Coleman and Livingston Stone NFH's are designed to produce healthy juveniles (smolts or pre-smolts). Sanitary conditions are maintained during fish incubation by disinfecting (with iodophor) all equipment between uses with different raceways. Fish are observed on a daily basis for irregularities. Examinations of juveniles are performed routinely to assess health status and detect problems before they progress into clinical disease or mortality. Dead and moribund fish are removed from rearing units. Necropsies are conducted on diseased and dead fish to diagnose cause of death. Appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) are used to alleviate disease-contributing factors. The California-Nevada Fish Health Center conducts applied research on-site to control disease epizootics. More complete descriptions of relevant pathogens and disease epizootics at Coleman NFH are presented in Section 10.5 (Disease management).

Smolt Development Indices
Fall Chinook Salmon
Data on smolt development are limited for fall chinook salmon at Coleman NFH. Results from saltwater challenges and gill ATPase experiments have been somewhat contradictory, with later release groups showing higher survival rates in the saltwater challenge experiment and earlier release groups showing higher gill ATPase activity (Free and Foott 1998). Despite this discrepancy, data indicate that fall chinook salmon from a wide range of fork lengths (61 to 92 mm) have the ability to osmoregulate (Foott and Williamson 1997), including salmon at the current size of release (68 mm).

Late-fall Chinook Salmon

Data on smolt development are also limited for late-fall chinook salmon. Based on saltwater challenges and gill ATPase experiments from brood year 1994 through 1997, late-fall chinook salmon at Coleman NFH have reached an advanced degree of smolt development by early November. In addition, degree of smoltification was not related to fork length after late-fall chinook reached approximately 110 mm (CA-NV FHC, unpublished data). Current mean fork length (134 mm) of late-fall chinook salmon at release is well above this.

Steelhead Trout

Reliable data on smolt development of steelhead trout at Coleman NFH are not currently available.

Use of Natural Rearing Methods

Beginning in brood year 2001, natural rearing techniques will be evaluated for implementation at a larger-scale with steelhead trout at Coleman NFH. At Coleman NFH, the pre-release rearing pond has recently been modified to incorporate several elements of natural-type rearing elements, including: 1) several in-water structures have been added to simulate natural-type cover; 2) a fabric screen has been placed around the pond to minimize interactions between juvenile steelhead trout and humans (juveniles will be fed without human interaction); 3) juveniles in the pre-release pond will be reared at a reduced density; 4) overhead bird netting has been removed from the pre-release pond to expose juvenile steelhead to potential avian predation (predator avoidance training); and, 5) sprinklers are situated to continuously spray water onto the pond surface to minimize visibility, light transmission, and avian predation. Juvenile steelhead from the pre-release pond will be monitored and compared to steelhead reared in standard hatchery raceways for physiological indications of stress and smoltification. Steelhead in the pre-release rearing pond will also be coded-wire tagged to evaluate contribution rates (an index of survival).

JUVENILE RELEASES

10.1 Juvenile release levels and release strategies

Release levels and strategies for fall, late-fall, and winter chinook salmon and steelhead trout are described below. Release levels for the past twelve years are also presented. For more complete historical data on releases of chinook salmon from Coleman and Livingston Stone NFH's refer to Appendix 10A. For historical data on steelhead/rainbow trout releases see Appendix 10B.

Fall Chinook Salmon

The annual release target for fall chinook salmon propagated at Coleman NFH is twelve million smolts, at about 90/lb (mean FL = 75mm, typical range 45-95). Fall chinook salmon are liberated into Battle Creek below the Coleman barrier weir during April.

The release strategy employed during recent years at Coleman NFH separates the total number fall chinook salmon into two groups of approximately six million fish each. Each of the two large groups of fall chinook smolts are released into Battle Creek en-masse. The first scheduled release of fall chinook salmon generally occurs about April 15, and the second group is liberated approximately 7-10 days later. Fall chinook salmon are released in large groups (i.e., two groups of 6 million) to reduce potential negative in-river effects on natural salmonid populations and to increase survival of hatchery-origin fish. Releasing fall juveniles in April reduces potential negative effects to in-river natural populations by decreasing the duration of concurrent residence of hatchery- and natural-origin fall chinook salmon in the Sacramento River. Survival of hatchery-origin fall chinook may benefit from the en-masse release strategy by "swamping" potential predators in the Sacramento River.

Analyses of post-release emigration patterns show that fall chinook smolts released from Coleman NFH travel downstream rapidly, in large pulses, with few fish exhibiting delayed emigration. Emigration past the RBDD typically begins about 1.5 days after release into Battle Creek. By the fourth day after release, the vast majority of fall chinook salmon have passed RBDD (Figure 10-1). Emigration downstream of Red Bluff occurs at an equally rapid rate. Juvenile monitoring conducted during 1998 and 1999 by the CDFG at Knights Landing (RM 90) showed that the majority of fall chinook smolts emigrate past that location one to three weeks post-release (Snider and Titus 2000). These data also showed that marked fall chinook salmon from Coleman NFH are seldom captured at Knights Landing after May. This emigration rate equates to a sustained rate of at least nine miles per day through Battle Creek and the Sacramento River, 181.5 miles downstream to Knights Landing.

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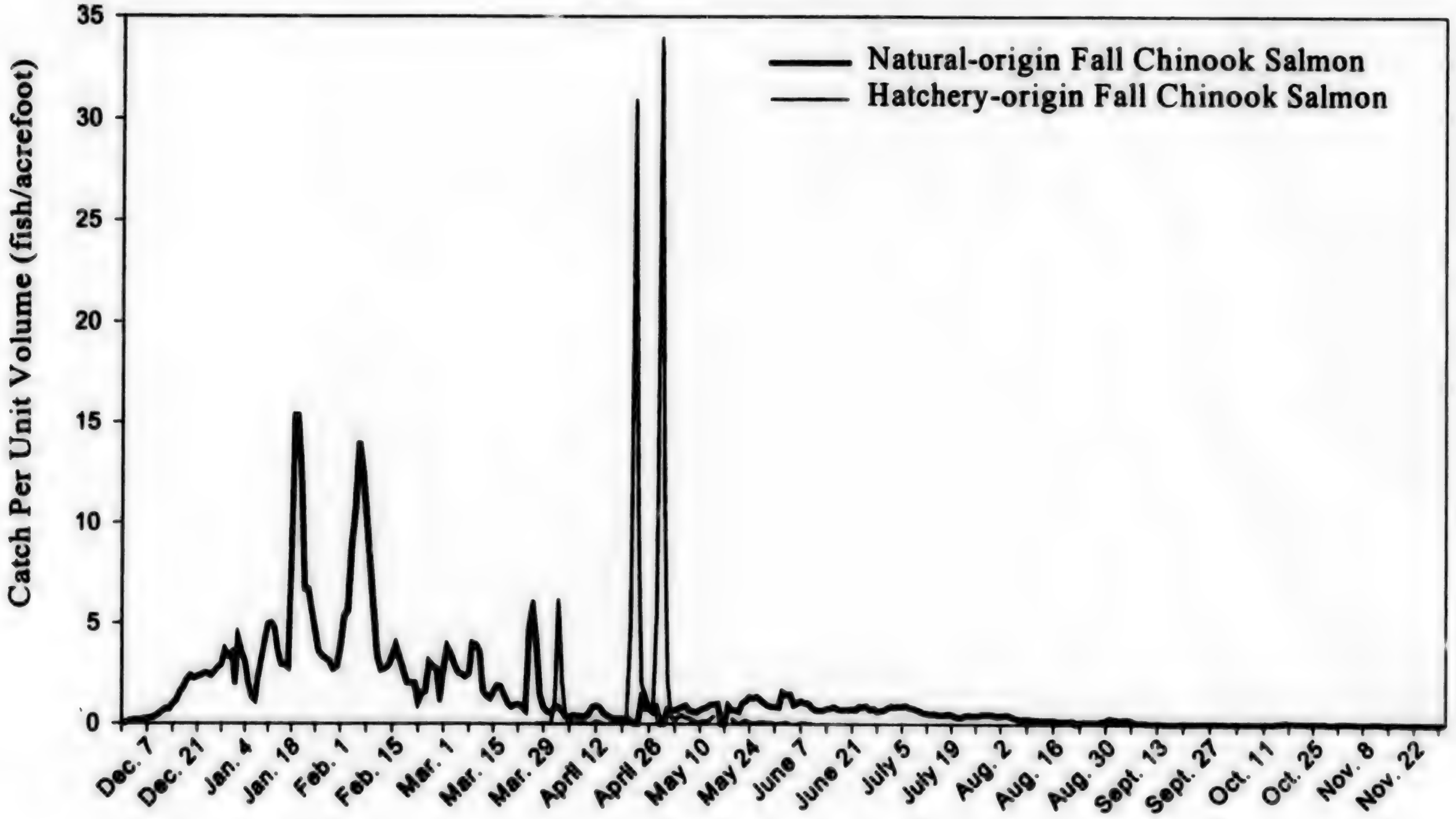

Figure 10-1. Catch per unit volume (CPUV) of hatchery- and natural-origin juvenile fall chinook salmon, brood year 1998. Data are from rotary screw traps operated on the Sacramento River, Red Bluff Diversion Dam (river mile 243). Displayed CPUV for natural-origin fall chinook salmon has been smoothed by calculating 3-day rolling averages. Daily CPUV is shown for hatchery-origin fall chinook salmon. Hatchery-origin juveniles were released at Coleman National Fish Hatchery, Battle Creek. Hatchery release dates were March 31 and April 20, 21, 27 and 28, 1999.

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Fall chinook salmon production at Coleman NFH averaged almost 18.5 million fish per year over the last 12 years (Table 10-1). Smolt production has remained stable at about 12 million annually, with the remainder being released as fry. Releases of fall chinook fry were recently stopped to eliminate potential impacts to natural stocks. Prior to 1962, fall chinook production levels frequently exceeded 30 million annually, with the vast majority of juveniles released at the fry stage (Figure 10-2). Proposed fall chinook salmon releases total approximately 12 million smolts (Table 10-2).

Table 10-2. Anticipated numbers of juvenile fall chinook salmon to be released from Coleman National Fish Hatchery (NFH) annually. Fish will be released into Battle Creek at Coleman NFH or into the Sacramento River at the Red Bluff Diversion Dam (RBDD).

Release number (x1,000)	Average fork length at release (mm)	Release location	Release timing	Purpose
200	<50	Sacramento River below RBDD (RM 243)	Feb - Apr	Experimental - Lower River Study
12,000	75	Battle Creek @ Coleman NFH (Creek Mile 5.7)	Mar - Apr	General Production

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Table 10-1. Fall chinook salmon production at Coleman National Fish Hatchery, brood years 1988-1999.

Brood Year	Fry		Smolt		Total Released	Other Experimental Production	Total Production
	Number	Fish/lb	Number	Fish/lb			
1988	10,541,697	500-600	11,630,957	107-136	22,172,654	500	22,173,154
1989	4,668,645	400-453	12,181,281	73-88	16,869,926	28,000	16,897,926
1990	10,634,814	341-550	12,752,877	86-156	23,387,691	1,315,331[a]	24,703,022
1991	11,193,016	343-518	14,149,518	80-133	25,342,534	0	25,342,534
1992	123,743	273	11,814,965	109-172	11,938,708	16,580	11,955,288
1993	4,548,719	419-579	12,129,576	103	16,678,295	24,497	16,702,792
1994	2,901,303	349-418	12,984,090	122-205	15,885,393	318,301	16,203,694
1995	7,543,621	432-527	12,354,953	69-156	19,898,574	13,969	19,912,543
1996	7,983,601	390-568	12,441,975	78-125	20,425,576	8,304	20,433,880
1997	8,203,920	500	12,775,199	104-205	20,979,119	6,541	20,985,660
1998	1,236,788	290-833	12,549,278	58-192	13,786,066	13,400	13,799,466
1999	0	0	11,701,384	90[b]	11,701,384	195,134[c]	11,896,518
Average	5,798,322		12,455,504		18,255,493	161,713	18,438,874

a Includes 1,259,936 eyed eggs transferred to Feather River State Fish Hatchery.

b Estimated value.

c These fish were released as fry in March 1999 at Red Bluff Diversion Dam (RM 243) or Clarksburg (RM 42.5).

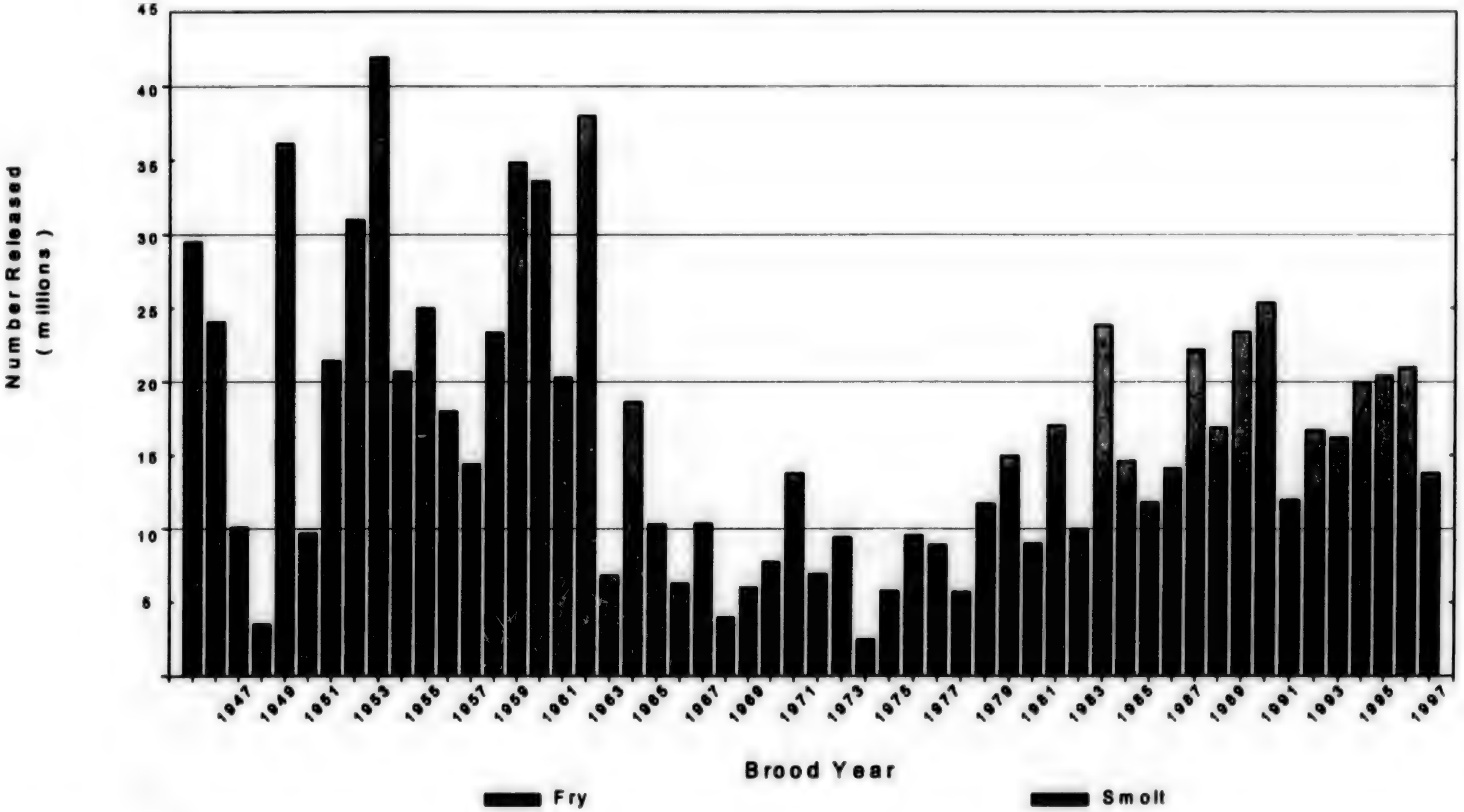

Figure 10-2. Number of fall chinook salmon fry and smolts released into the Sacramento River system from Coleman National Fish Hatchery, brood years 1945 to 1997.

Late-fall Chinook Salmon

Late-fall chinook juveniles are reared at Coleman NFH for approximately one year. The brood year 2001 production target is approximately 975,000[1] yearling smolts to be released into Battle Creek. The majority of late-fall chinook are released in January at approximately 13/lb (mean FL = 135 mm). Alternative release times and locations are utilized to accommodate the requirements of various investigations or, infrequently, to facilitate pond/water management at the hatchery. As much as half the annual production of late-fall chinook salmon may be released off-site and prior to January for various experimental investigations. During recent years, experimental release groups totaling between 120,000 and 300,000 late-fall chinook were liberated into the lower Sacramento River or Delta during November or December (see section 10.12 and Appendix 10C for a discussion of increased straying associated with Delta release groups and possible negative impacts). Current investigations involving experimental releases for late-fall chinook salmon include November and December releases at Battle Creek designed to serve as surrogates for emigrating ESA-listed spring chinook salmon[2], an investigation of survival related to delta inflow and export ratios, and an evaluation of survival through the lower Sacramento River as related to operations at the Delta-Cross channel. Release locations and timing for experimental releases from Coleman NFH are coordinated with and approved by the NMFS and CDFG on an individual basis.

Late-fall chinook salmon production at Coleman NFH averaged almost 800,000 fish per year over the last 12 years (Table 10-3). Total production of late-fall chinook has varied greatly since 1974, ranging between almost 207,000 (1990) and over 2.5 million (1981; Figure 10-3). Proposed future late-fall chinook salmon releases total over 1 million smolts (Table 10-4).

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[1] Total production is authorized up to 1,500,000 given a concurrent reduction in the number of steelhead produced (see NMFS 1996 - Biological Opinion).

[2] Release of these surrogate groups is coordinated with the Interagency Ecological Program and the Delta Assessment Team.

Table 10-3. Late-fall chinook salmon production at Coleman National Fish Hatchery, brood years 1988-1999.

Brood Year	Smolt		Other Experimental Production	Total Production
	Number	Fish/lb		
1988	662,079	11-25	100	662,179
1989	908,746	20-25	0	908,746
1990	203,387	13-15	3,317[a]	206,704
1991	302,982	13	1,189	304,171
1992	325,244	14	15,102	340,346
1993	744,723	14-22	15,815	760,543
1994	632,867	13-23	0	632,867
1995	930,964	13-18	6,820	937,784
1996	1,081,108	9-40	5,056	1,086,164
1997	1,138,223	14-37	16,006	1,154,225
1998	1,102,540	19-40	142,986[b]	1,245,526
1999	1,117,325	11-22	7,368	1,124,693
Average	762,516		17,814	780,390

[a] Eyed eggs transferred to USFWS FAO Red Bluff.

[b] Includes 125,892 fry put into the Coleman NFH abatement pond, an estimated 44,137 escaped into Battle Creek.

Table 10-4. Anticipated numbers of juvenile late-fall chinook salmon to be released from Coleman National Fish Hatchery (NFH) annually.

Release number (x1,000)	Average fork length at release (mm)	Release location	Release timing	Purpose
210	135	Battle Creek @ Coleman NFH (Creek Mile 5.7)	Nov-Dec	Experimental - Spring Chinook Surrogates
300	135	Various Delta Locations	Dec -Jan	Experimental - Delta Survival Evaluations
500	135	Battle Creek @ Coleman NFH (Creek Mile 5.7)	January	General Production

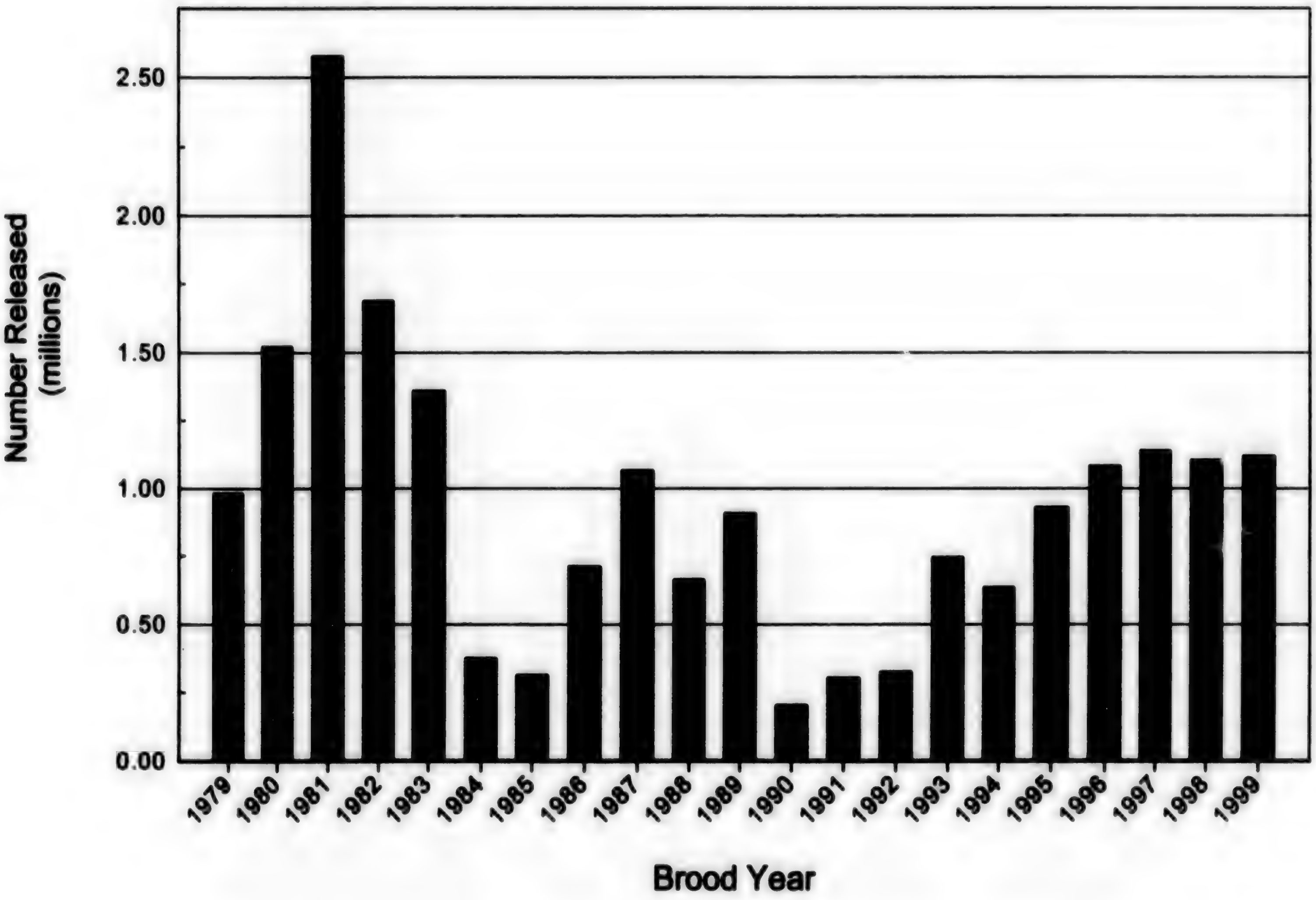

Figure 10-3. Number of late-fall chinook salmon smolts released from Coleman National Fish Hatchery into the Sacramento River system, brood years 1979 to 1999.

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Winter Chinook Salmon
Winter chinook juveniles are propagated at Livingston Stone NFH until January, when, at approximately 80/lb (mean FL = 85 mm), they are transported to the mainstem Sacramento River at Caldwell Park, Redding (RM 299), for release. Winter chinook salmon are transported to the release location in two groups to avoid the catastrophic loss of an entire brood year caused by potential difficulties experienced in transport or release (e.g., traffic accident). Hatchery releases of winter chinook are conducted at dusk to reduce the risk of predation while juveniles are acclimating to the receiving environment.

Winter chinook salmon production has varied greatly (Table 10-5), depending mostly on the number of broodstock collected. Annual releases of winter chinook salmon from Coleman NFH from 1945 through 1997 are shown in Figure 10-4. In the near future, the Service anticipates releasing approximately 200,000 juvenile winter chinook salmon from Livingston Stone NFH annually.

Table 10-5. Winter chinook salmon production at Coleman (CNFH) and Livingston Stone (LSNFH) National Fish Hatcheries and Bodega Marine Laboratory (BML), brood years 1989-1999.

Brood Year	Facility	Pre-Smolt		Other Experimental Production	Total Production
		Number	Fish/lb		
1989	CNFH	3,203	68	0	3,203
1990	CNFH	1,286	76	0	1,286
1991	CNFH	11,582	60	0	11,582
1992	CNFH	26,433	74	971[d]	27,404
1993	CNFH	18,723	70	998[d]	19,721
1994	CNFH	43,346	74	662[e]	44,008
1995	CNFH	51,267[a]	183	316[d];332[e]	51,915
1996	BML, CNFH	4,718[b]	205	0	4,718
1997	BML, CNFH, LSNFH	21,271[b]	86	10,066[f]	31,337
1998	LSNFH	153,908	58-119	503[d];504[e];211[g]	155,126
1999	LSNFH	30,840[c]	46-123	500[d];500[e];204[g]	32,044
Average		33,325		1,433	34,759

a Includes 1,131 produced from captive x natural broodstock crosses.
b All were produced from captive x captive broodstock crosses.
c Includes 4,318 produced from captive x natural broodstock crosses.
d Transferred to Bodega Marine Lab for captive broodstock.
e Transferred to Steinhart Aquarium for captive broodstock.
f Transferred to Steinhart Aquarium for display purposes only.
g Held at Livingston Stone NFH for captive broodstock.

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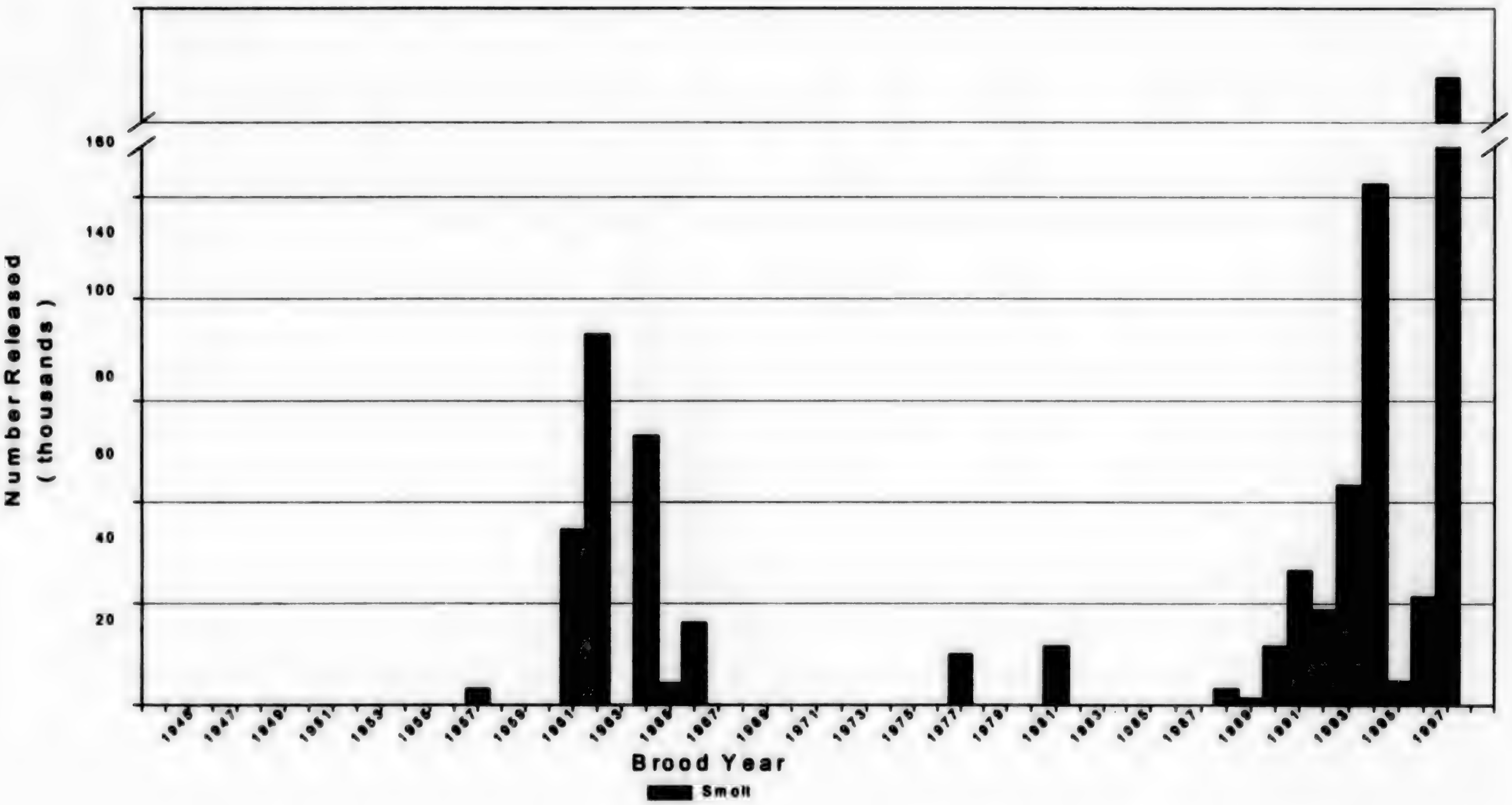

Figure 10-4. Number of winter chinook salmon released from Coleman National Fish Hatchery into the Sacramento River system, brood years 1957 - 1997.

Steelhead Trout

The Coleman NFH release target for steelhead trout is approximately 600,000 yearling smolts to be released into the mainstem Sacramento River at Bend Bridge (RM 258) in January, at approximately 4/lb (mean FL = 195 mm).

Until recently, all of the steelhead trout reared in the hatchery's pre-release pond (< 150,000) have been released directly into Battle Creek because the configuration of that rearing pond (e.g., sloped walls, gravel bottom) makes it difficult to collect and transport fish to an off-site release location. This release strategy was considered to pose an increased potential for risks of predation on and competition with natural-origin salmonids in lower Battle Creek. Therefore, beginning in January 2001, hatchery personnel will collect brood year 2000 steelhead trout from the pre-release pond and transport them to the Sacramento River at Bend Bridge for release. It is anticipated that Service personnel may not be able to collect some (perhaps 1-10,000) of these steelhead from the pre-release pond. These steelhead will be released directly into Battle Creek by lifting the fish screen and crowding them from the pond.

Steelhead trout production at Coleman NFH averages almost 1 million fish per year over the last 12 years (Table 10-6). Since the beginnings of the steelhead trout program in 1947, total production has varied greatly, ranging from just a few thousand during the program's founding years to a high of almost 3 million smolts in 1965 (Figure 10-5, also see Appendix 6B). Proposed steelhead trout releases total approximately 600,000 smolts (Table 10-7).

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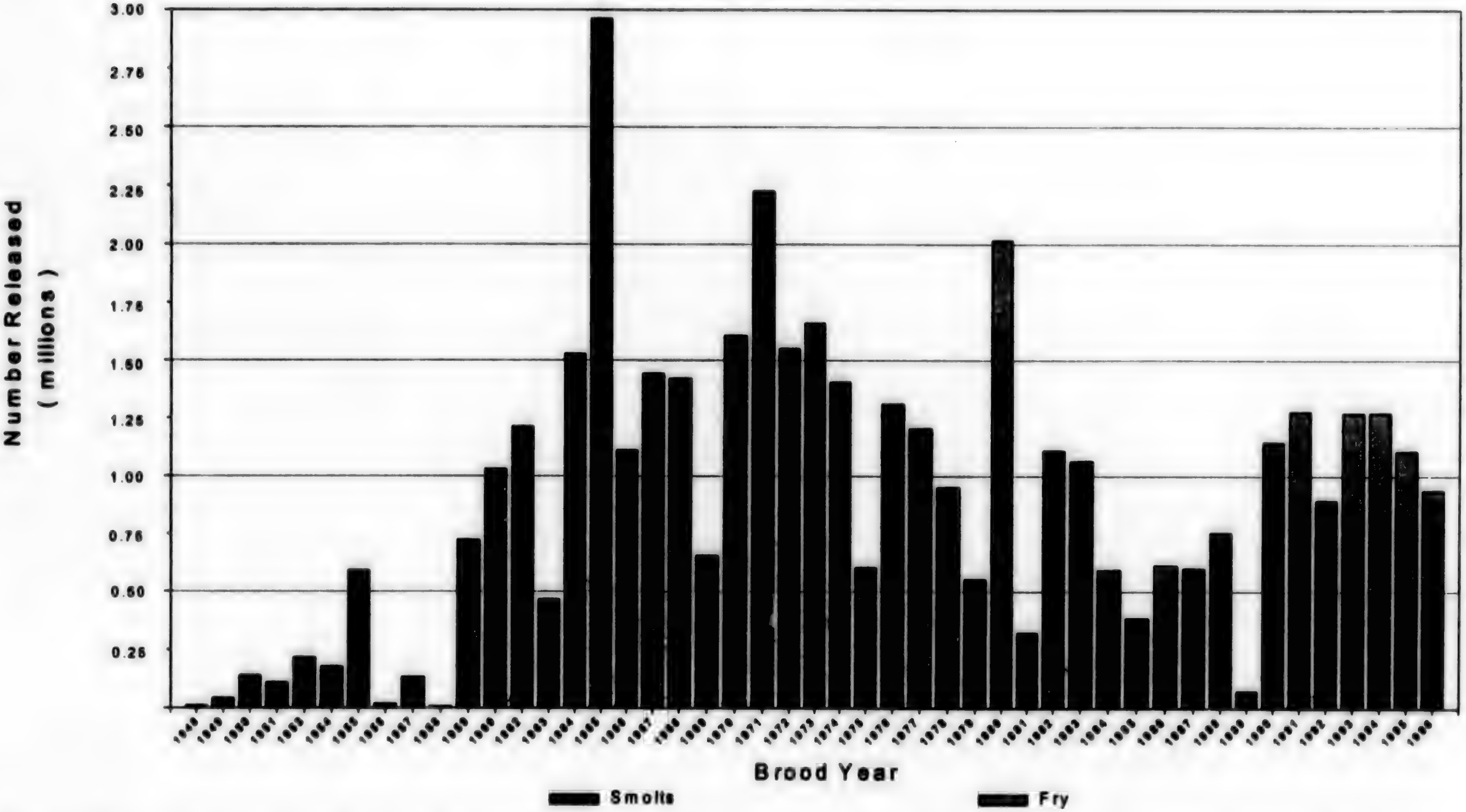

Figure 10-5. Number of steelhead and non-anadromous rainbow trout fry and smolts released from Coleman National Fish Hatchery into the Sacramento River system, brood years 1948 to 1996.

Table 10-6. Coleman National Fish Hatchery steelhead trout production for brood years, 1988 -1999.

Brood-year	Fry		Smolt		Total Released	Other Experimental Production	Total Production
	Number	Fish/lb	Number	Fish/lb			
1988	0	0	754,480	4	754,480	350	754,830
1989	0	0	74,240	3	74,240	0	74,240
1990	573,239	36	547,377	4	1,120,616	615,043[a]	1,735,659
1991	384,336	121	895,113	4	1,279,449	0	1,279,449
1992	0	0	895,930	5	895,930	0	895,930
1993	516,213	244	756,108	5	1,272,321	5,109	1,277,430
1994	571,776	193	701,857	5	1,273,633	516	1,274,149
1995	574,273	248	531,134	4	1,105,407	0	1,105,407
1996	399,328	158	540,287	4	939,615	0	939,615
1997	117,434	108	544,579	4	662,013	200	662,213
1998	49,928	222	496,525	4	546,453	0	546,453
1999	0	0	519,923	4	519,923	1,309	521,232
Average	265,543	166	617,419	4	882,963	39,255	922,217

[a] Includes 463,573 eyed eggs transferred to Mokelumne State Fish Hatchery and 151,470 smolts transferred to Feather River State Fish Hatchery.

Table 10-7. Anticipated numbers of juvenile steelhead trout to be released from Coleman National Fish Hatchery (NFH), annually.

Release number (x 1,000)	Average fork length at release (mm)	Release location	Release timing	Purpose
1 - 10	195	Battle Creek @ Coleman NFH (Creek Mile 5.7)	January	General production
590 - 600	195	Sacramento River @ Bend Bridge (RM 258)	January	General production

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10.2 Acclimation procedures

Juvenile fall and late-fall chinook salmon and steelhead trout from Coleman NFH do not undergo any deliberate periods of acclimation to receiving waters prior to release. The majority of juveniles released from Coleman NFH are liberated in either Battle Creek (fall and late-fall chinook salmon and approx. 1-10,000 steelhead trout) or the upper Sacramento River (steelhead trout). These release locations are in close proximity to Coleman NFH and require only a short travel time. Additionally, physical properties of the rearing and receiving waters are similar during the time of year when releases occur.

Winter chinook salmon released from Livingston Stone NFH are reared in water obtained from Shasta Reservoir, located at RM 314 on the Sacramento River. Release location for winter chinook salmon is the upper Sacramento River at Redding (RM 299). Because winter chinook salmon are reared and released into water very near to their rearing location (i.e., minimal travel time) and with essentially identical physical (e.g., temperature, turbidity) and chemical (e.g., acidity, dissolved gas concentrations, alkalinity and hardness) characteristics, there is no need to acclimate them prior to release. However, as noted above, winter chinook salmon are released at dusk to reduce the risk of predation while they acclimate to receiving environments.

10.3 Marks applied, and proportions of the total hatchery population marked

A portion of the juvenile salmonids propagated at Coleman NFH are typically given an externally identifiable mark by removing (clipping) the adipose fin and inserting a coded-wire tag[3]. Over the past fifty years, the proportions of juvenile fall and late-fall chinook salmon and steelhead trout that have been marked at the Coleman NFH have varied. Until the 1990's, the marking rates at Coleman NFH were generally low and marks were applied only to specific study groups. Recently, marking rates at Coleman NFH have increased substantially. Currently, all programs except the fall chinook salmon production program have a 100% mark rate (Table 10-8). Winter chinook salmon released from Livingston Stone NFH (and previously Coleman NFH) have been 100% marked and coded-wire tagged since 1991. A brief discussion of marking and tagging rates by stock is presented below.

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[3] All chinook salmon at Coleman NFH that are marked with an adipose fin-clip are also tagged with a coded-wire tag. Coded-wire tag recovery information from marked and tagged chinook salmon is typically used for stock assessments and fishery investigations. Steelhead trout at Coleman NFH are mass-marked (adipose fin-clipped), and may or may not have coded-wire tags.

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Table 10-8. Projected release number, anticipated number marked (fin clip), mark rates, and mark type for all runs/species produced at Coleman and Livingston Stone National Fish Hatcheries, brood year 2000. Ad = Adipose-fin clipped, CWT = coded-wire tagged, and PIT = passive integrated transponder tagged.

Stock	Number Released	Number Marked	Mark Rate (%)	Mark Type
Coleman				
Fall Chinook[a]	12,000,000	1,700,000	14	Ad-CWT
Late-fall Chinook	975,000	975,000	100	Ad-CWT
Steelhead Trout	390,000	390,000	100	Ad only
	210,000	210,000[b]	100	Ad-CWT
Livingston Stone				
Winter Chinook	150,000	150,000	100	Ad-CWT
Winter Chinook	1,000	1,000	100	Ad-CWT/PIT[c]

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a An additional 200,000 marked and tagged fall chinook salmon will be released for an investigation of survival during emigration through the lower Sacramento River.

b These steelhead will receive *both* an adipose fin-clip and carry a coded-wire tag for various experiments at Coleman NFH.

c 1,000 winter-run chinook salmon juveniles are transferred to the captive broodstock program annually. PIT tagging allows non-lethal identification of family group origin.

Fall Chinook Salmon

Prior to brood year 1995, few fall chinook salmon were marked annually at Coleman NFH (200,000 - 300,000; 0-3% of number released), and marking of fall chinook salmon was generally limited to smaller study groups. In 1995, a large-scale fall chinook marking program was initiated to evaluate survival through the Sacramento River. During that year, approximately 333,000 fall chinook were marked and coded-wire tagged into each of three ponds at Coleman NFH, yielding approximately one million marked fall chinook salmon (8% mark rate). Since 1996, one million fall chinook salmon have been marked and tagged annually at Coleman NFH. Also beginning in 1996, the marking strategy for fall chinook salmon was changed to produce a better representation of marked fish within the total hatchery population. The new marking and tagging strategy was designed to mark 8% (36,000) into each of the 28 rearing ponds at Coleman NFH. The marking rate for fall chinook produced at Coleman NFH will increase again for brood year 2000, when 1.9 million (approx. 16%) of the hatchery's releases will be marked and coded-wire tagged prior to release. This substantial increase will be accomplished by using the automated mass-marking machine (Northwest Marine Technology, Inc., Shaw Island, WA). This increase in marking rate for fall chinook salmon at Coleman NFH should be considered temporary until: 1) the fishery management agencies investigate long-term marking needs throughout the Central Valley; and, 2) the Service secures long-term funding to facilitate increased marking rates.

Late-fall Chinook Salmon
Beginning with brood year 1992, all late-fall chinook salmon have been adipose fin-clipped and coded-wire tagged prior to release. The primary purpose for 100% marking of late-fall chinook is to differentiate hatchery-origin late-fall chinook salmon from naturally-produced, ESA-listed, winter chinook salmon. Complete marking of hatchery-origin late-fall chinook allows visual discrimination of the two groups at downstream sampling locations and pumping/salvage facilities in the delta. Marking all late-fall produced at Coleman NFH requires over two months to complete (early October through mid-December).

Winter Chinook Salmon
Since 1991, all winter chinook salmon produced either at Coleman NFH (1991 - 1997) or Livingston Stone NFH (1998 -1999) have been adipose fin-clipped and coded-wire tagged. Marking and tagging of winter chinook salmon is necessary to evaluate the success of the hatchery's supplementation program. Ocean recoveries of coded-wire tagged winter chinook salmon have also provided valuable information that has been used to evaluate and regulate harvest by the commercial salmon fishery. The 100% mark rate also allows personnel to distinguish between hatchery- and natural-origin salmon, which assists future broodstock mating strategies/pairings. In addition to clipping adipose fins and coded-wire tagging, approximately 1,000 winter chinook salmon captive broodstock are tagged with passive integrated transponder (PIT) tags prior to extended rearing as captive broodstock.

Steelhead Trout
Prior to 1997, the highest mark rate that had been applied to juvenile steelhead trout at Coleman NFH was 25%. Beginning in 1997, all steelhead trout produced at Coleman NFH have been mass-marked with an adipose fin-clip. Some of these fish have also been coded-wire tagged as well. This effort was undertaken following negotiations with CDFG to implement a complete marking program of all hatchery-origin steelhead in the Central Valley.

10.4 Disposition of fish identified at the time of release as surplus to approved levels

Surplus inventories at the time of release are unlikely to occur at either Coleman NFH or Livingston Stone NFH. No juvenile winter chinook salmon will be culled . Production inventories for stocks propagated at Coleman NFH are conducted periodically throughout the duration of incubation and rearing. In the unlikely event that surplus production needs to be culled it will be accomplished at the earliest possible stage of development, ideally prior to the eyed-egg stage.

10.5 Disease management

The occurrence and spread of infectious disease in the hatchery environment is caused by the interaction of pathogen(s), environment, and a susceptible host. An infection may occur, for example, when a virulent pathogen meets a susceptible fish in a stressful environment. Infection doesn't necessarily guarantee disease occurrence. Both healthy hatchery and natural fish harbor many infections throughout their life, oftentimes without direct detrimental effects on apparent health or survival. Natural and hatchery environments contain a variety of microorganisms that may include bacteria, parasites, virus, and fungi that are capable of causing disease. From a fish health perspective, the occurrence of disease in natural salmonids is considered more of a phenomenon than a problem (Hastein and Lindstatd 1991).

Naturally-produced salmonids in the Sacramento River tend to be susceptible to infection by the same pathogens as salmonids cultured at Coleman NFH and Livingston Stone NFH. Susceptibility to similar infections is a consequence of similar ancestry and co-mingling by free-ranging parental stocks. Most pathogens endemic to Sacramento River salmonids evolved with their salmonid hosts and are not recent introductions. Endemic pathogens which have caused significant health problems in Central Valley salmon hatcheries include: *Yersinia ruckeri, Flexibacter columnaris, Ceratomyxa shasta, Ichthyophthirius multifilis,* and *Nanophyetus salmincola* (Cox 1993). Numerous other bacterial, parasitic, and fungal species have also been identified as being pathogenic to hatchery populations under appropriate conditions.

Hatchery fish that are raised in a stressful environment may be more prone to infection or amplification of existing infections than the same fish reared in a natural environment. This phenomenon is not necessarily a result of the method of fish reproduction or rearing (i.e., hatchery or natural), but rather, is a consequence of rearing conditions in the hatchery environment that could predispose these individuals to infection. For example, hatchery rearing practices that result in crowded or unsanitary conditions may result in increased susceptibility to some types of infection.

The following discussion will focus on the obligate pathogens (pathogens with specific host requirements) which are considered to be potentially the most devastating at Coleman NFH, and pose the greatest potential risk to natural populations (Scott Foott, CA-NV FHC, pers. comm.). Facultative pathogens (pathogens that opportunistically infect their hosts) have also been responsible for disease outbreaks at Coleman NFH, but are not considered as potentially devastating as obligate pathogens. Four obligate pathogens have occurred at Coleman NFH, including: (1) infectious hematopoeitic necrosis virus (IHNV), (2) *Myxobolus cerebralis* or Whirling disease, (3) Rosette Agent, and (4) *Renibacterium salmoninarum* or Bacterial Kidney Disease (Table 10-9).

Table 10-9. Important obligate pathogens of juvenile fish produced at Coleman and Livingston Stone National Fish Hatcheries, 1985-present. Pathogens marked with (X) have caused significant health problems in the specified stocks and pathogens marked with (O) are known to have infected the specified hatchery stocks but have not caused significant health problems. FCS = fall chinook salmon, LFS = late-fall chinook salmon, WCS = winter chinook salmon, and STT = steelhead trout.

Pathogen	FCS	LFS	WCS	STT
Infectious hematopoietic necrosis virus (IHNV)	X	X		O
Renibacterium salmoninarum (causes BKD)		X	X	O
"Rosette agent"		O	X[a]	
Myxobolus cerebralis (causes whirling disease)				O

[a] The "Rosette agent" is suspected of causing morbidity and mortality in some captive broodstock winter chinook salmon at Bodega Marine Laboratory and Steinhart Aquarium.

Infectious Hematopoeitic Necrosis Virus

Infectious hematopoeitic necrosis virus (IHNV) is an acute rhabdoviral infection characterized by dark coloration, exopthalmia, ascites, and hemorrhaging on skin and internal organs. IHNV is indigenous to North America and to chinook salmon populations of the upper Sacramento River (Parisot and Pelnar 1962). The virus is found in both natural- and hatchery-origin chinook salmon in the Central Valley.

Mode of IHNV Transmission

Transmission of the IHNV is believed to occur primarily at the time of spawning, either by horizontal (water to juvenile) or vertical (adult to juvenile) transmission. The mode of IHNV transmission at Coleman NFH has not been conclusively identified and is under investigation (S. Foott, pers. comm.). Several possibilities for the source of infection, listed in order of assumed likelihood (Foott 1998), include:

- Virus shed into Battle Creek above the hatchery's Intake 3 by adult late-fall chinook in early winter.
- Transfer of virus from late-fall chinook spawning operations at Coleman NFH or from late-fall adults in Battle Creek via a transfer mechanism (e.g., contaminated equipment, clothing, birds).
- Vertical transmission from parent via intra-ovum route, which is later amplified in the hatchery population by horizontal transmission.
- Survival of virus on the surface of eggs which later infects hatching fry.
- Virus shed into the Battle Creek water supply from another host (reservoir).

Vertical transmission from parent to progeny via eggs is considered to be an unlikely mode of IHNV transmission (Foott 1998). All eggs collected at Coleman and Livingston Stone NFH's

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are water hardened with an iodophor disinfectant to inactivate IHNV and other pathogens potentially passed from parent to progeny.

To test the hypothesis that waterborne transmission is the source of IHNV in juvenile chinook at Coleman NFH, a series of challenge studies were conducted by biologists from CA-NV FHC. A 1990 study indicated that only high levels of virus (10^4-10^5 plaque forming units (PFU)/ mL) resulted in 25% mortality or greater. Results of a 1997 investigation showed that exposure to as little as 100 PFU/ mL of IHNV for one minute can infect juvenile chinook, but mortalities resulting from infections at this level of exposure were less than 1% after 19 to 25 days. Furthermore, "sentinel studies" during 1998, in which juvenile chinook were exposed to water from Intakes 1 and 3, failed to show infection among fish in the study groups, even though production fish subsequently became infected with IHNV (S. Foott pers. comm.).

While conclusive evidence does not identify waterborne transmission via Intake 3 as the source of the IHNV at the Coleman NFH, this is considered to be the most likely mode of transmission into the hatchery (S. Foott pers. com.). Late-fall chinook have been present above Intake 3 in many high-flow years when they can escape past the Coleman barrier weir. It is possible that virus particles shed into the creek via mucus, urine, feces, and carcasses of late-fall adults could remain infectious in creek water for at least seven weeks and could be re-suspended with associated sediments during rain events (Wedemeyer et al. 1978 in Foott 1998). Water from Intake 3 has historically been used to supply the nursery raceways where fall chinook are first transferred to ponds in December and January, thus potentially exposing the fish directly to IHNV- contaminated water.

Another possible mode of IHNV transmission to chinook salmon at Coleman NFH is via terrestrial or avian predators, with subsequent spreading of the virus within the hatchery by transferring contaminated equipment between raceways (Foott 1998). The potential spread of virus by avian and mammalian predators may be the most difficult factor to control, but efforts have been made to reduce predator access to hatchery raceways by enclosing raceways with fencing and netting. Equipment and outerwear are disinfected with an iodophor solution to reduce the probability of IHNV transmission between raceways.

Virulence of IHNV in the Sacramento River

The Sacramento River strain of IHNV is considered moderately virulent to juvenile chinook salmon. At Coleman NFH, IHNV infections have induced a range of cumulative mortalities *in individual raceways* ranging from ≤0.1% to 41% (Foott 1998). Mortality within the hatchery is generally <10% for individual raceway populations. Overall fall chinook salmon mortality caused by IHNV at Coleman NFH is estimated at 2 - 4 % (USFWS, RBFWO unpublished data).

Hatchery Stocks Susceptible to IHNV

Fish stocks susceptible to IHNV at Coleman and Livingston Stone NFH's include fall, late-fall, and winter chinook salmon. IHNV is commonly detected in 46-100% of the adult fall, late-fall, and winter chinook salmon returning to Coleman NFH. Late-fall chinook salmon show the highest incidence of infection with IHNV. From 1992 to 1995 returning adult hatchery-origin late-fall adult chinook salmon tested positive for IHNV infection at a rate of 71-100% (S. Foott pers. comm.). Steelhead trout are resistant to disease from the Sacramento strain of IHNV (La Patra et al. 1993).

IHNV primarily affects juvenile fall chinook salmon at Coleman NFH. Few late-fall juvenile chinook rearing units have experienced outbreaks since 1990. IHNV infection has not been detected in juvenile winter chinook salmon at Coleman NFH or Livingston Stone NFH from 1990 to the present.

Outbreaks of IHNV in juvenile fall chinook salmon at Coleman NFH have occurred frequently since the hatchery's construction in the early-1940's. Most outbreaks began in late-February or early-March, when water temperatures ranged between 8 and 11°C. Water temperatures above 11 °C. are reported to be inhibitory to IHNV infection (Parisot and Pelnar 1962, Amend 1970). In the 1990's, IHNV outbreaks in Coleman NFH fall chinook juveniles occurred in eight of ten brood years. These outbreaks resulted in large losses of juveniles at the hatchery and the release of IHNV-infected smolts. No IHNV was detected in brood year 1999 fall chinook salmon at Coleman NFH. Although conclusions regarding the effectiveness of the hatchery's new ozone water treatment plant are premature, it is noteworthy that brood year 1999 represents the first year that the hatchery's ozone water disinfection system has been operated throughout the duration of fall chinook incubation and rearing, and no IHNV was detected during that brood year. The last year when no IHNV outbreaks occurred at Coleman NFH was brood year 1991.

Progression of IHNV after Release of Fish from Coleman NFH

Progression of IHNV disease continues after infected juveniles are released from the hatchery. Infected fall chinook juveniles from Coleman NFH have been detected 183 river miles downstream of the hatchery for up to 15 days post-release (Free and Foott 1998). The prevalence of infection in the out-migrant groups has ranged from 9-16%; however, the majority of infected fish were asymptomatic. Culling of symptomatic fish prior to release did not appear to significantly reduce the incidence of infection in out-migrants.

Until 1999, acute outbreaks of fall chinook salmon with IHNV prompted decisions to modify target release schedules by releasing several groups of severely infected fish early. Early releases of infected fall chinook at Coleman NFH, triggered by high mortality and morbidity in the hatchery ponds, was intended to decrease amplification and horizontal transmission of disease within the infected group(s), and was believed to maximize survival and eventual contribution.

In a Biological Opinion issued by NMFS on February 18, 1999, the strategy of conducting early releases for IHNV-infected groups of fall chinook salmon at Coleman NFH was identified as possibly conferring a risk to natural populations of fall and winter chinook in the Sacramento River. Although IHNV transmission from hatchery juveniles to natural juveniles has not been documented in the natural environment, post-release sampling has shown progression of disease within infected groups released from Coleman NFH. Because of the potential for disease

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transmission to natural populations, the Service and the NMFS established a specific release protocol with criteria to minimize the potential for negative impacts on natural salmonid populations (NMFS 1999 Biological Opinion).

Transmission of IHNV from Hatchery- to Natural-origin Salmonids after Release

The likelihood of transmitting diseases from hatchery fish to natural fish in the Sacramento River system is not known, and research in other systems has led to conflicting conclusions on the subject. Hindar et al. (1991) report that farmed salmon contribute to the decline of many Atlantic salmon populations through the introduction of parasites and pathogens. Steward and Bjornn (1990), however, claim there is little evidence of transmittance of diseases or parasites from hatchery to natural salmonids in the Pacific Northwest. The majority of pathogens infecting fish at Coleman and Livingston Stone NFH's are endemic to the Sacramento River system and thus salmonids native to the system would have evolved some resistance to them.

Laboratory studies conducted by biologists at CA-NV FHC indicate that uninfected juvenile chinook salmon in close proximity to fish heavily infected with IHNV (10^4-10^5 PFU/ mL) will develop symptomatic IHNV (Foott 1996a). Brief oral contact with artificial mucus infected at 10^4-10^5 PFU/ mL, to simulate nipping behavior, likewise resulted in viral infection, but with lower mortality (Foott 1998). The results of laboratory studies indicate low level of ecological risk to natural populations if infected hatchery fish are released into the Sacramento River system. In a 1996 study, no IHNV was detected in naturally-produced fall chinook fry from Battle Creek, despite their close association with IHNV-infected adult fall chinook carcasses (Foott 1996b). Laboratory studies to examine IHNV transmission from infected hatchery to natural fall chinook salmon showed no transmission of IHNV to natural-origin salmon, even when ratios of infected hatchery fish to uninfected natural fish were 20 to 1 (Foott et al. 2000). Further, no IHNV-infected juveniles of natural-origin have been collected from Battle Creek and the Sacramento River during regular pathogen monitoring surveys (S. Foott pers. comm.).

Myxobolus cerebralis or Whirling Disease

The causative agent for whirling disease, *Myxobolus cerebralis,* is a protozoan which afflicts salmonids during the parasitic phase of its life cycle. To date, *M. cerebralis* has been detected at Coleman NFH only in steelhead during 1985. More than one million steelhead fry were destroyed in 1985 after they were found to be infected with *M. cerebralis* cysts. The source of *M. cerebralis* discovered at Coleman NFH is believed to have been a commercial trout processing facility in the Battle Creek drainage (Modin 1998). Although no clinical signs of whirling disease were seen in the steelhead during 1985, they were destroyed to avoid introducing more *M. cerebralis* into the Sacramento River system. Since 1985, *M. cerebralis* has not been detected among steelhead fry at Coleman NFH (CA-NV FHC, unpublished data). *M. cerebralis* was detected in natural rainbow trout collected from Battle Creek in 1999; however, none displayed symptoms of whirling disease. Laboratory analysis showed the infections occurred at low levels, and the pathogens were not thought to significantly affect the health of the fish (True 2001).

Rosette Agent

In 1993, mortality and morbidity were observed in 1-5 year old captive broodstock of Sacramento River winter chinook salmon held in captivity at University of California at Davis, BML. Captive adults were infected with a systemic protist termed the rosette agent. Two forms of disease were typical of infected fish (Arkush et al. 1997). Because of the slow replication rate of the agent, infection with rosette agent does not become apparent until after transfer to seawater. Experimental infections evaluated at three and six months after inoculation demonstrated the virulence of the rosette agent for both chinook and coho, and a progressively greater resistance to disease in rainbow, brown and brook trout (Arkush et al. 1998). The source of infection is suspected to be Battle Creek water supply where the early stages of fish rearing took place (Arkush et al. 1997).

The mode of transmission to winter chinook broodstock held at BML is uncertain, but considering that up to 32% of late-fall chinook salmon returning to Battle Creek have been infected with the rosette agent, it is possible that rosette agent is endemic to Battle Creek and the source of infection was the hatchery water supply (Arkush et al. 1998). Furthermore, adult winter chinook salmon sampled from the trap in the fish ladder of the Coleman barrier weir did not show evidence of infection with rosette agent.

Nineteen ninety-five was the first year that rosett agent diagnoses were attempted in late-fall, fall, and winter chinook and steelhead trout (Table 10-10). Rosette agent was observed only in late-fall adults (except for one doubtful fall chinook infection), primarily from those returning to Battle Creek. No clinical signs of disease were observed. This suggests a Battle Creek origin for this pathogen. The agent has not been found in juvenile fish of other stocks raised at Coleman NFH. No modifications to hatchery management practices have been suggested.

Biologists from the CA-NV FHC tested tissue from 36 hatchery-origin winter chinook salmon, 1 natural-origin spring chinook salmon, and 6 Sacramento suckers sampled during trapping operations at the Coleman NFH barrier weir from March 13 through May 1, 1997. None showed any sign of the rosette agent in various culture and histological tests (S. Foott, memo dated Sept. 29, 1997). Experimental infections indicate that, in addition to chinook salmon, *O. mykiss* are also susceptible to infection with the rosette agent, but at a much lower rate (Arkush et al. 1998). To date, steelhead trout at Coleman NFH have not tested positive for the rosette agent (CA-NV FHC unpublished data).

Table 10-10. Coleman National Fish Hatchery adult broodstock infection history for the rosette agent by kidney imprint. Salmon were collected from Battle Creek (BC) and the Sacramento River at the Keswick fish trap (KEW). RA+ = rosette agent positive.

Brood-year	Chinook Salmon (percent of tested)			Steelhead Trout
	Fall	Late-fall	Winter	
1994	not tested	not tested	not tested	not tested
1995	0%	BC and KEW 26%	0% (0/43)	0%
1996	0%	BC 30% KEW 0% (unmarked)	unknown	0%
1997	0%, (1 fish RA+, doubtful)	BC 20% BC 0% (unmarked)(14)	0% (0/13 BC trap)	0%
1998	0%		0%	0%
1999	not tested		0%	0%

Renibacterium salmoninarum or Bacterial Kidney Disease

Renibacterium salmoninarum, the cause of bacterial kidney disease (BKD), is a chronic disease of salmonids worldwide (Fryar 1981 in Foott 1996a). and is a primary concern in propagation programs at Coleman NFH and Livingston Stone NFH. This bacteria has been found in winter chinook juveniles, and was associated with severe episodes of BKD both at Coleman NFH and at off-site facilities (BML, Steinhart Aquarium, and Livingston Stone NFH). Treatments with erythromycin at these facilities exhibit short-term control.

10.6 Risk assessment framework

While substantial information exists to quantitatively determine levels of negative impacts resulting from various hatchery activities such as broodstock congregation and collection, hatchery water supply, and facility operations, we cannot explicitly quantify the negative effects of juvenile releases upon naturally produced salmonids. This inability to quantify impacts is due to the complex biology of salmon and steelhead trout and the multitude of other actions that simultaneously affect natural salmonid populations. As a result, we will assess impacts of juvenile releases from Coleman and Livingston Stone NFH's based substantially on a qualitative assessment of risks.

The purpose of this risk assessment is to describe, in a broad sense, impacts to ESA-listed and candidate species of anadromous salmonids occurring as a result of releasing hatchery-origin chinook salmon and steelhead from Coleman and Livingston Stone NFH's. Releases of juvenile salmonids from Coleman NFH and Livingston Stone NFH have been analyzed in regard to potential risks posed to each stock of naturally-produced salmonid. This assessment of risk or "jeopardy" is based on the concept of population viability. In other words, at what level do proposed release numbers and strategies threaten the continued existence of naturally-produced salmonids.

We have evaluated potential risks of juvenile releases both at the scale of ESU's (to evaluate potential risks at the scale of populations) and at the scale of the hatchery's local watershed (to evaluate potential risks to the Battle Creek restoration process). In determining risks to Battle Creek populations, we limited our consideration to the lower six miles of the creek (i.e., below the Coleman barrier weir). All juvenile salmon and steelhead released into Battle Creek are liberated below the Coleman barrier weir. Since juvenile salmonids in lower Battle Creek cannot pass above the Coleman barrier weir, lower Battle Creek is the only reach of the creek where an ecological interaction between natural- and hatchery-origin juveniles can occur. Because we consider impacts only to the section of Battle Creek below the Coleman barrier weir, the level of risk identified in this analysis may not necessarily be indicative of an impact to the entire Battle Creek population of a specific stock.

Impacts of juvenile releases have been characterized as No Impact, Low Impact, Moderate Impact, and High Impact. Definitions of these impacts are adopted from the Bonneville Power Administration (BPA 1997).

No Impact:	Activity will not affect fish abundance.
Low Impact:	Activity likely to result in a small change of abundance, but would remain within expected year-to-year variability, and would not ultimately affect population viability.

Moderate Impact: Action is likely to produce a moderate change in abundance similar in magnitude to changes in abundance witnessed during atypical conditions (e.g., drought). Should conditions or impacts persist, population viability may be affected.

High Impact: Likely to cause large immediate changes in abundance similar to a catastrophic natural event.

Releasing hatchery-origin salmon and steelhead into Battle Creek and the Sacramento River has the potential to impact natural populations of ESA-listed and candidate species via: 1) predation; 2) competition/displacement; and, 3) disease transmission. The following section presents a brief explanation of these potential impacts, and presents a set of criteria to objectively assess potential risks resulting from releasing hatchery-origin juveniles from Coleman NFH into Battle Creek and the Sacramento River.

Predation

Significant predation may occur when yearling salmonids are released during the emergence of natural salmon (Steward and Bjornn 1990). It is well recognized that larger juvenile hatchery salmonids can prey on natural salmonids, if the hatchery fish are large enough (Horner 1978, Menchen 1981, Partridge 1985, Partridge 1986, Beauchamp 1987, Hillman and Mullan 1989, Beauchamp 1990, Viola and Schuck 1991, Martin et al. 1993; Cannamela 1993). Sholes and Hallock (1979 in Cannamela 1992) estimated 500,000 yearling chinook salmon released in California's Feather River consumed 7,500,000 emergent chinook salmon and steelhead trout fry. Hallock (1989) reported sampling of stomach contents of steelhead trout yearlings released into Battle Creek in February and March 1975 revealed an average of 1.4 fall chinook salmon per steelhead stomach.

The ability of a hatchery-origin chinook salmon or steelhead to locate, identify, pursue, capture, and swallow prey items is a function of prey and predator abundance, spatial and temporal overlap, environmental conditions, predator/prey size relationships, and predatory skill. In this risk analysis, we have examined potential impacts of predation on natural salmonids following the releases from Coleman and Livingston Stone NFH's by assessing the following criteria:

1. Spatial and temporal overlap between hatchery and natural populations: Hatchery-release results in substantial temporal and spatial overlap with naturally produced salmonids (i.e., release occurs during peak emergence/rearing periods at or near primary nursery/rearing areas,
2. Predator/prey size ratio: 3:1 predator/prey size ratio; with minimum predator FL = 120 mm
3. "Training time" for hatchery fish to become effective predators
4. Environmental conditions: turbidity < 24 nephelometric turbidity units (NTU)

Relative Abundance - Spatial and Temporal Overlap

Predator and prey must co-occur for predatory interactions to occur. If predators and prey are not in the same location at the same time, predation is not possible. If both groups are present in substantial numbers there exists an increased potential for predatory interactions. In examining relative abundance for hatchery and natural stocks for this analysis we use life history information for naturally-produced stocks as presented in Fisher (1994), Johnson et al. (1992) and Vogel and Marine (1991). Hatchery release information is based on general release sizes and timing (as presented above).

Predator/prey Size Relationships and the Onset of Piscivory

For a hatchery-origin salmonid to be a predator on natural-origin fish, the predator must have a substantial size advantage over the potential prey. Pearsons and Fritts (1999) reported the size of prey items for some salmonids (coho salmon and steelhead trout juveniles) can be up to 46% of the predator's length. Size criteria suggested by Parkinson et al. (1989 in Cannamela 1992) indicate predators rarely select prey items exceeding ⅓ their length. Gape width has been suggested as a major constraint to the onset of piscivory (Mittlebach and Persson 1998), and has been proposed as a major factor determining the maximum size of prey a predator can ingest (Hoyle and Keast 1987, 1988 in Mittelbach and Persson 1998). However, prey ingestion may also be a function of both gape width and throat diameter (Petrusso 1998). In examination of stomach contents of fish in British Columbia, Gregory and Levings (1998) observed age-0 coho and chinook salmon as small as 90 mm demonstrating piscivory.

Feeding habits of Sacramento River fall chinook salmon were investigated by Petrusso (1998), by analyzing the stomach contents of 189 juvenile fall chinook salmon captured from April though June of 1996. Fork lengths of these fish ranged between 33 and 91 mm. Minimal levels of piscivory were observed in that investigation; however, the author did not observe evidence of predation upon salmonids. Larval fish (3-19 mm total length), potentially cyprinids and catostomids, comprised approximately 2.4% of the diet of juvenile fall chinook salmon. Chironomids were identified as the predominant prey item (approx. 60% of diet). For this analysis of potential predation of natural-origin salmonids by hatchery-origin chinook salmon and steelhead, we consider 120 mm FL as the minimum size necessary to successfully prey on other salmonids (BPA 1997).

Training Time

Following the release of artificially propagated salmonids from Coleman or Livingston Stone NFH's, hatchery-reared salmonids likely experience a lag time associated with prey (food) recognition and perhaps additional lag time associated with the development of effective capture techniques. The feeding activity of piscivorous fishes can be parsed into the following phases: 1) food recognition; 2) positioning; 3) approach; 4) seizure; and, 5) ingestion. The ability to recognize novel prey and to develop effective pursuit and capture tactics must be "learned" by juveniles which have been reared on diets of manufactured granules and pellets in the hatchery environment. Ware (1971) reported that hatchery-reared rainbow trout required an average of four days of experience before approaching novel prey. In that investigation, the distance from which a hatchery-origin test fish attacked novel prey doubled by the 12th day.

Environmental Conditions

Environmental conditions such as flow and turbidity affect the ability of a predator to locate and capture prey. Most piscivorous fishes visually detect and attack prey (Hobson 1979 in Gregory and Levings 1998). Environmental conditions reducing visual acuity (i.e., turbidity) have been shown to reduce the effectiveness of predators (Gregory and Levings 1998, Ginetz and Larkin 1976). Chapman and Bjornn (1969; as cited in Maslin et al. 1996) report moderate levels of turbidity (24 NTU) reduce the feeding efficiency of chinook salmon..

Competition/Displacement

Competition for food and space may occur when hatchery- and natural-origin chinook salmon and steelhead overlap in time and space and compete for a limited supply of resources (Steward and Bjornn 1990, Cannamela 1992). Most direct evidence for hatchery releases affecting natural salmon through competition comes from studies on coho salmon. Nickelson et al. (1986) reported that pre-smolt releases of hatchery-origin coho salmon were associated with decreased densities and abundance of naturally-produced juveniles. Nielsen (1994) observed agonistic encounters between hatchery- and natural-origin coho that resulted in displacement of natural coho from their usual territories.

Greater aggressiveness of hatchery fish has been suggested as the mechanism by which hatchery coho are able to out-compete naturally produced coho for territory. Behavioral experiments provide evidence that hatchery coho salmon and steelhead trout can indeed be more aggressive than natural fish (Swain and Riddell 1990, Berejikian et al. 1996), especially in situations where hatchery fish are larger or food is a limiting resource (Berejikian et al. 1996, Fisher and Pearcy 1996). Nielsen (1994) observed a greater occurrence of agonistic encounters among natural and hatchery coho than among natural coho in unstocked streams, an increase that lasted until smoltification and emigration.

We assessed the potential for competition/displacement of natural-origin salmonids resulting from hatchery releases based on criteria suggested by Steward and Bjornn (1990) and McMicheal et al. (1999), including:

1. Spatial and temporal overlap (i.e., release occurs during peak emergence/rearing periods at or near primary nursery/rearing areas).
2. Carrying capacity of the receiving environment (may be exceeded).
3. Prior residence: hatchery fish are released but fail to disperse or are in place prior to the emergence of natural juveniles.

4. Relative body size of hatchery and natural fish: hatchery fish may be larger than natural stocks[4].

Disease Transmission

Infectious disease is considered to be a normal component in the life history of both hatchery-reared and natural salmonids in the Sacramento River. These populations, due to their similar parental stock (free-ranging broodstock of mixed origin) and exposure to similar water supplies, tend to be infected by the same pathogens. Most pathogens endemic to Sacramento River salmonids evolved with their salmonid hosts and are not recent introductions. Endemic pathogens other than IHNV and BKD which have caused significant health problems in Central Valley salmon hatcheries include: *Yersinia ruckeri, Flexibacter columnaris, Ceratomyxa shasta, Ichthyophthirius multifilis,* and *Nanophyetus salmincola* (Cox 1993). Numerous other bacterial, parasitic, and fungal organisms have also been identified as being pathogenic to hatchery populations under appropriate conditions. Although disease outbreaks are common in hatcheries, Steward and Bjornn (1990) state there is little evidence of transmittance of diseases or parasites from hatchery to natural salmonids. For this analysis of potential risk to natural populations, we focus on the potential risks of IHNV because this has been the major disease concern at Coleman NFH. However, recent construction of the ozone water treatment facility is expected to largely alleviate this situation in the future.

Direct evidence is lacking to conclusively show transmittance or amplification of an endemic disease or parasite to a natural salmonid population resulting from any hatchery propagation program. However, detecting and verifying pathways of disease dissemination within fish populations is complicated by uncertain interactions between disease and host, making cause-and-effect relationships difficult to determine. Theoretical aspects of disease dissemination processes in fish populations suggest that disease transmission and amplification may potentially result from hatchery propagation programs which release infected fish into natural environments to interact with natural populations. The likelihood of adverse impacts to natural populations is increased when hatchery releases are severely infected and very large in size, and when infected populations co-exist for extended duration with natural populations. Criteria used to assess the potential for disease transmission from hatchery-origin juveniles are:

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[4] A size difference exhibited between hatchery-released steelhead trout smolts and other naturally-produced salmon could also be a benefit by reducing the potential for competition/displacement, as the size difference may lead to differences in habitat selection. Hampton (1988) reports larger juveniles select deeper water and faster velocities further minimizing competition. Fry use low velocity areas at the stream margin and where substrate irregularities and other instream features create velocity breaks. As juveniles grow, they move away from the shoreline into higher velocity areas, especially for feeding (Rich 1997 in CDFG 1998).

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1. Hatchery-release results in substantial temporal and spatial overlap with naturally produced salmonids (i.e., release occurs during peak emergence/rearing periods at or near primary nursery/rearing areas)
2. Release group actively undergoing IHNV epizootic

10.7 Strategies designed to minimize potential negative impacts from juvenile releases

Minimize Temporal and Spatial Overlap

Release strategies for general production groups from Coleman NFH are designed to minimize the potential for negative impacts on naturally produced salmonids via the following strategies: 1) minimize the interaction time between hatchery- and naturally-produced juveniles in Battle Creek and the Sacramento River; 2) release fish at sizes that will minimize their impacts on naturally-produced juveniles; and, 3) release healthy fish.

To reduce or avoid impacts of hatchery-produced salmonids on their naturally produced counterparts, many fishery scientists advocate that hatchery releases be timed to minimize the duration of concurrent residence with natural-origin fish in the freshwater environment (e.g., Northwest Power Planning Council 1999, Integrated Hatchery Operations Team 1995). April releases of fall chinook salmon from Coleman NFH are timed to occur after the emigration cycle of naturally-produced salmonids which are often associated with high flow/turbidity events. Releases of late-fall chinook and steelhead from Coleman NFH are timed to coincide with high flow events in Battle Creek and the Sacramento River so they will move out of the system quickly (see Figure 10-1 for timing of juvenile outmigration of fall chinook in the upper Sacramento River and Appendix 10D for outmigration of juvenile salmonids in Battle Creek).

Chinook salmon and steelhead are released from Coleman NFH at the time of smoltification. This release strategy is intended to decrease likelihood that hatchery fish will remain in the upper Sacramento River system and interact with naturally-produced fish. Spawning and rearing strategies previously used at Coleman NFH resulted in the release of up to eight million fall chinook salmon fry (45 mm FL) from January through March. This practice was discontinued after 1998 because it was considered to confer an increased potential for risk to naturally produced chinook salmon because of substantially overlapping periods of rearing in the upper Sacramento River.

Disease Transmission

The surest way to reduce potentially deleterious effects of disease transmission and amplification from hatchery to natural populations is to produce and release healthy fish. In addition to minimizing the potential for impacts to natural stocks, propagation of healthy juveniles contributes to achieving program goals of mitigation, augmentation, supplementation, or conservation/preservation. Fish culture practices and health management programs at Coleman NFH and Livingston Stone NFH are designed to produce healthy smolts. Many precautionary measures are taken to reduce the risk of infection to juvenile fish at Coleman NFH and to minimize potential impacts after release into the natural environment. The general strategy involves maintaining a good rearing environment, good nutrition, and minimizing exposure to pathogens and stress.

While evidence has not yet conclusively identified Battle Creek surface water as the source of IHNV or the rosette agent at Coleman NFH, measures are nevertheless being taken that will reduce the risk of contaminating the hatchery's water supply with either of these obligate pathogens. Substantial re-design leading to future modifications to the Coleman NFH water intake system are underway (see Section 4.1). In addition, ozone water treatment, reported to inactivate IHNV at concentrations of 70 mg/hr/L (Wedermeyer et al. 1978 in Foott 1998), will be used to disinfect up to 30,000 gpm of water used for incubation and rearing at the Coleman NFH. It is anticipated that completion of the ozone water disinfection system at Coleman NFH will substantially alleviate disease concerns, both on-station and after release.

Release strategies at Coleman NFH are also designed to minimize potential for disease transmission and amplification resulting from large releases of hatchery fish. Releases of fall and late-fall chinook salmon and steelhead trout are conducted in a manner such that hatchery fish will emigrate en-masse and rapidly from the river environment, thus decreasing the duration of interaction with natural stocks in the Sacramento River (see Section 10.1 on releases of juveniles). This is accomplished by releasing fish at the proper time and size, and at an advanced state of smoltification. Analysis of emigration data verifies that fall and late-fall chinook salmon, and steelhead trout released from Coleman NFH emigrate rapidly through the river. Little is known regarding the potential for disease transmission to natural populations in the estuarine and ocean environments.

10.8 Analysis of risks resulting from releases of hatchery-origin fall chinook salmon

A summary of impacts to natural salmonid populations resulting from releases of juvenile fall chinook salmon from Coleman NFH is presented in Table 10-11. Detailed explanations follow.

Fall chinook salmon comprise the largest production program at Coleman NFH. Approximately 12 million fall chinook smolts are released annually into Battle Creek from mid- to late-April. Impacts of predation, competition/displacement, and disease transmission occurring as a result of releases of hatchery-origin fall chinook salmon from Coleman NFH are expected to be low because: 1) hatchery-origin fall chinook emigrate during a time when few naturally produced salmonids emigrate; 2) hatchery-origin fall chinook emigrate en-masse and rapidly from the freshwater environment; and, 3) hatchery-origin fall chinook are not piscivorous during their life-stage (size) at release.

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Table 10-11. Summary of impacts to natural salmonid populations resulting from releases of juvenile fall chinook salmon from Coleman National Fish Hatchery. See text (Section 10.6) for definitions of impact ratings and descriptions of criteria.

	Impact Rating					
	Battle Creek			ESU		
Natural-Origin Species / Run	Predation	Competition / Displacement	Disease	Predation	Competition / Displacement	Disease
Fall Chinook	None	Low	Low	None	Low	Low
Late-fall Chinook	None	Low	Low	None	Low	Low
Winter Chinook	None	Low	Low	None	Low	Low
Spring Chinook	None	Low	Low	None	Low	Low
Steelhead	None	Low	Low	None	Low	Low

Predation

Occurrences of predation to natural-origin chinook salmon and steelhead resulting from releases of hatchery-origin fall chinook juveniles are expected to be minimal. The average size of fall chinook smolts at the time of release in April is 80 mm, with a maximum size of 95 mm (Figure 10-6). With the exception of newly-emerged late-fall chinook salmon and steelhead trout, all naturally produced salmonids potentially co-occurring with hatchery-origin fall chinook salmon after their release in April are larger, and are therefore unlikely to be consumed by juvenile fall chinook salmon (Table 10-12). Young-of-the-year (YOY) late-fall chinook salmon and steelhead are emerging during April when Coleman NFH releases fall chinook salmon. However, extensive predation by hatchery-origin fall chinook salmon is considered unlikely because juvenile fall chinook salmon are thought to be largely non-piscivorous at the lifestage (size) when they are liberated from Coleman NFH. Because of their small body size, gape limitation, and non-piscivorous feeding patterns (learned during hatchery-rearing), hatchery-origin fall chinook salmon are believed to be generally non-piscivorous throughout their emigration from the Sacramento River. Therefore, predatory interactions involving fall chinook smolts upon naturally produced salmonids are expected to be minimal.

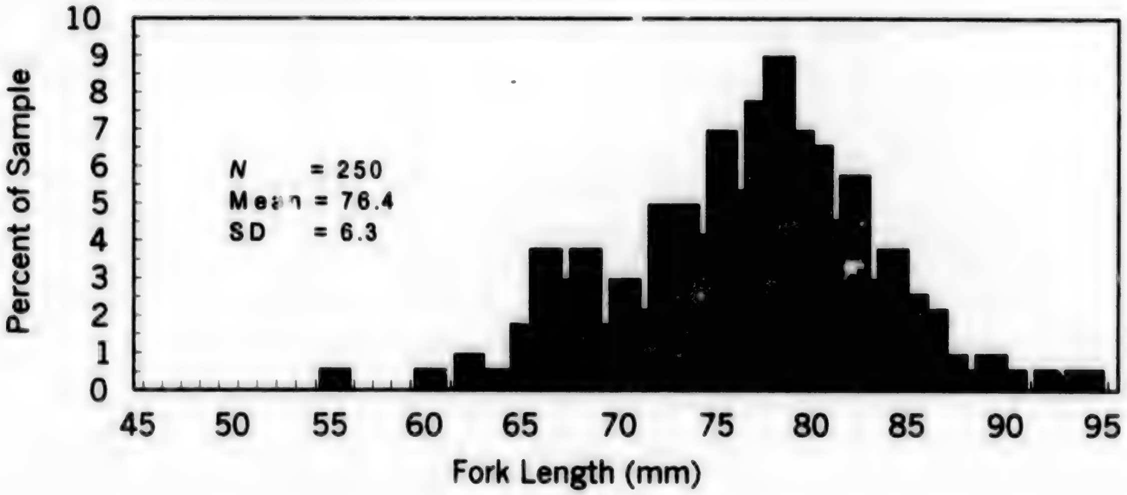

Figure 10-6. Length frequency distribution of Coleman National Fish Hatchery fall chinook salmon smolts. Data displayed are from brood year 1993, but remain indicative of general mean length and length range.

Table 10-12. Length ranges of naturally-produced chinook salmon and steelhead trout potentially co-occurring in Battle Creek and the Sacramento River with hatchery-origin late-fall chinook salmon during April.

	Fork length (mm)	
Stock	Young-of-Year	Yearling
Fall Chinook[a]	34 - 89	none
Late-fall Chinook[a]	22 - 40	201- 270
Spring Chinook[a]	none	73 - 120
Winter Chinook[a]	none	99 - 201
Steelhead[b]	20 - 75	140-200

a Length ranges for natural-origin chinook salmon were taken from a daily length increment table (Sheila Green, Department of Water Resources).

b Steelhead trout length ranges were back-calculated from scale analysis for upper Sacramento River *Onchorynchus mykiss* (CDFG, unpublished data).

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Competition /Displacement
Releases of fall chinook smolts from Coleman NFH occur during a time when relatively few natural-origin salmon and steelhead are emigrating from Battle Creek and the upper Sacramento River (see Appendix 10D for timing of juvenile salmonid outmigration in Battle Creek, a tributary of the upper Sacramento River). Yearling natural-origin late-fall, spring, and winter chinook salmon and steelhead emigrate from the Sacramento River primarily from November through March, during periods of high flows and high turbidity (USFWS, RBFWO unpublished data). Likewise, juvenile fall chinook salmon emigrate soon after emergence from the gravels, primarily from January through March (USFWS, RBFWO unpublished data; Johnson and Martin 1997; Johnson et al. 1992). Winter chinook YOY emigrate primarily from August through March. The few winter chinook salmon remaining in the Sacramento River during April and March range in size from approximately 99 to 270 mm (Johnson et al. 1992) and would have a competitive advantage over smaller fall chinook salmon.

Newly-emergent YOY late-fall chinook salmon and steelhead co-occur in the upper Sacramento River with hatchery-origin fall chinook following hatchery releases in April. Potential interactions including competition/displacement between hatchery-origin fall chinook salmon and YOY late-fall chinook and steelhead are reduced as a result of rapid migration tendencies exhibited by hatchery-origin fall chinook salmon. Monitoring of juvenile emigration patterns conducted by the Service at the RBDD shows that April releases of fall chinook salmon smolts from Coleman NFH travel downstream rapidly, in large pulses, and few fish delay emigration (USFWS, RBFWO unpublished data; see Section 10.1 for emigration data on hatchery releases for a more complete discussion). Post-release emigration past RBDD typically begins about 1.5 days after release at Battle Creek. By the fourth day following release, nearly all of the hatchery-origin fall chinook salmon have emigrated past RBDD (RM 243).

Hatchery-origin fall chinook also emigrate rapidly through the Sacramento River downstream of Red Bluff. Juvenile monitoring conducted by CDFG at Knights Landing (RM 90) showed that the majority of fall chinook smolts released from Coleman NFH migrated past that location at two to three weeks post-release, and no marked hatchery-origin fall chinook salmon were captured after May (CDFG, Sacramento, CA unpublished data). This pattern of fall chinook emigration timing equates to a sustained rate of travel of at least nine miles per day in Battle Creek and the Sacramento River.

Some natural-origin chinook salmon juveniles (YOY fall chinook and yearling late-fall, spring, and winter chinook) may remain in the upper Sacramento River until April and move downstream in-concert with hatchery releases of fall chinook salmon. Natural-origin juveniles emigrating with hatchery-origin fall chinook salmon may benefit from increased survival due to schooling, predator swamping, and protective measures designed primarily to benefit survival of hatchery-origin fall chinook salmon. Large-scale releases of fall chinook salmon smolts from Coleman NFH are often afforded protective measures to facilitate downstream migration. Protective measures may include: pulse flows from Keswick and Shasta dams, release timings which assure passage through RBDD, curtailed water diversion at the Glen-Colusa Irrigation

District (GCID) and closure of the Delta Cross Channel gates. As a result of these protective measures, natural-origin salmonids that emigrate downstream with hatchery-origin fall chinook may benefit from increased survival.

Carrying Capacity of Lower Battle Creek

Releasing 12 million hatchery-origin fall chinook smolts into Battle Creek would likely greatly exceed the carrying capacity of that tributary if hatchery-origin fall chinook attempted to rear for an extended duration in that area. However, as shown by the Service's emigration monitoring programs at Battle Creek and at RBDD, hatchery-origin fall chinook salmon emigrate rapidly from Battle Creek and the upper Sacramento River. The majority of hatchery-origin fall chinook salmon emigrate past the RBDD between 1.5 and 4 days following liberation into Battle Creek.

Emigration patterns exhibited by natural-origin fall chinook salmon in lower Battle Creek are similarly large and rapid. Natural production of fall chinook salmon in Battle Creek for brood year1998 and 1999 are estimated at 14.2 million and 26.5 million, respectively, well beyond the expected carrying capacity of that system for extended rearing. However, nearly all of these natural-origin juveniles dispersed from Battle Creek from January through March, soon after emergence from the gravels (USFWS, RBFWO unpublished data). These data show that neither hatchery-origin nor natural-origin fall chinook salmon exhibit a propensity for extended rearing in lower Battle Creek. Rather, both hatchery- and natural-stocks of fall chinook salmon utilize lower Battle Creek as a migration corridor to facilitate rapid downstream emigration/dispersal.

Disease Transmission

Because hatchery-origin fall chinook salmon emigrate rapidly and en-masse from the upper Sacramento River, and the emigration timing of hatchery-origin fall chinook does not greatly overlap with emigration of natural salmonid populations, the potential for disease transmission to natural populations in the river environment is likely minimal. Although hatchery-origin fall chinook salmon co-occur in the upper Sacramento River with newly-emerged late-fall chinook and steelhead during a short time in April, the stocks are likely segregated on the micro-geographic scale as a result of habitat selection. Hatchery-origin fall chinook salmon also emigrate rapidly from the upper Sacramento River, averaging approximately nine miles per day. This rapid rate of emigration suggests minimal rearing in the upper river environment. To sustain this rapid rate of emigration, hatchery-origin fall chinook likely congregate in swiftly-flowing sections of the river, unlike newly-emergent natural-origin late-fall chinook and steelhead which tend to seek refuge at the river margins for extended rearing.

The new ozone water disinfection system at Coleman NFH is expected to largely ameliorate concerns of IHNV. In the event of IHNV outbreak at Coleman NFH, the Service will abide by the release strategies developed in cooperation with NMFS (NMFS 1999) to reduce the potential for negative impacts to natural salmonid populations.

10.9 Analysis of risks resulting from releases of hatchery-origin late-fall chinook salmon

Most late-fall chinook salmon from Coleman NFH are released as yearlings into Battle Creek in January. Additionally, during recent years, experimental groups of late-fall chinook have been released in November and December in Battle Creek and at various downstream locations in the lower river and delta. Total releases of late-fall chinook from Coleman NFH are approximately one million annually, with as much as one-third of the total number produced being released in the lower Sacramento River and delta for experimental investigations.

Potential interactions between naturally produced salmonids and hatchery produced late fall chinook salmon include predation, competition/displacement, and disease transmission. Because of their comparatively larger size and different release timing as compared to hatchery-origin fall chinook salmon, potential impacts to naturally produced salmonid populations may be greater for releases of late-fall chinook salmon from Coleman NFH (Table 10-13).

Table 10-13. Summary of impacts to natural salmonid populations resulting from releases of juvenile late-fall chinook salmon from Coleman National Fish Hatchery. See text (Section 10.6) for definitions of impact ratings and descriptions of criteria.

	Impact Rating					
	Battle Creek			ESU		
Natural-Origin Species / Run	Predation	Competition / Displacement	Disease	Predation	Competition / Displacement	Disease
Fall Chinook	Moderate	Low	Low	Moderate	Low	Low
Late-fall Chinook	Low	Low	Low	Low	Low	Low
Winter Chinook	Low	Low	Low	Low	Low	Low
Spring Chinook	Low	Low	Low	Low	Low	Low
Steelhead	Low	Low	Low	Low	Low	Low

Predation

The average size of hatchery-origin late-fall chinook salmon smolts at the time of release in January is 128 mm, with a maximum size of over 200 mm (Figure 10-7). The size ranges of naturally produced chinook salmon and steelhead potentially co-occurring with hatchery-origin late-fall chinook salmon in Battle Creek and the Sacramento River are shown in Table 10-14. Based on the body size of hatchery-released late-fall chinook salmon, size ranges of naturally-produced salmonid stocks, and predator-prey size constraints (i.e., prey ≤ ⅓ of predator length),

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hatchery-origin late-fall chinook could potentially consume naturally produced fall, spring, and winter chinook juveniles following their release from Coleman NFH (Table 10-14).

Although hatchery-origin late-fall chinook juveniles could potentially capture and consume spring and winter chinook juveniles, impacts from predation by late-fall chinook salmon are likely greatest on juvenile fall chinook salmon. Hatchery-origin late-fall chinook salmon are likely inefficient predators immediately following their release into Battle Creek. During January when late-fall chinook are released from Coleman NFH, fall chinook salmon are just beginning to emerge from the gravels. Inexperienced hatchery-reared late-fall chinook salmon are likely opportunistic feeders, and are therefore more likely to prey on the abundant and less-agile newly emerged fall chinook fry than winter and spring chinook salmon which are less abundant, larger, and more agile. With an average rate of emigration of over 30 miles per day through Battle Creek and the Sacramento River (USFWS, RBFWO unpublished data), hatchery-origin late-fall chinook salmon smolts would likely travel a substantial distance down the Sacramento River system prior to becoming efficient predators on larger, more evasive organisms.

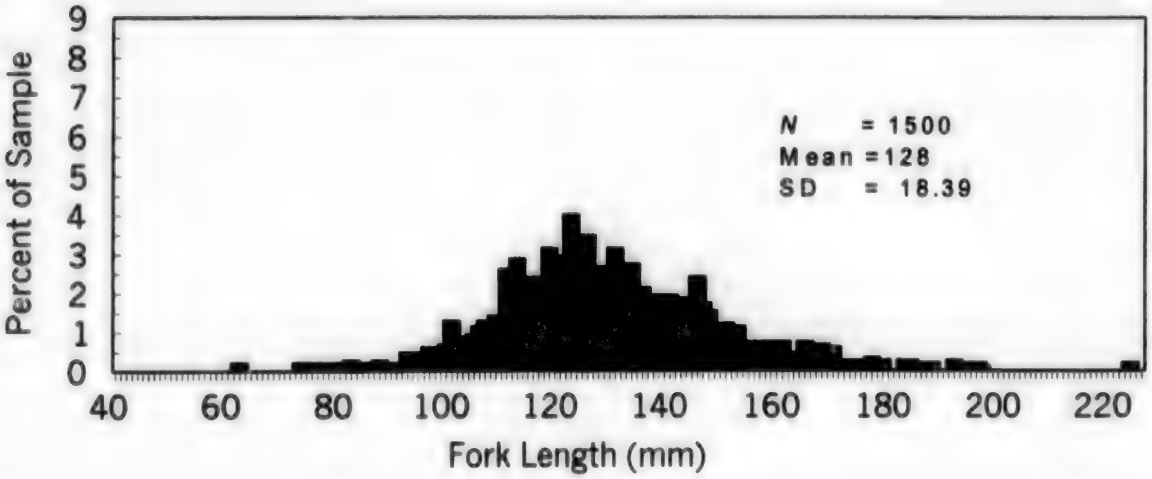

Figure 10-7. Length frequency distribution of Coleman National Fish Hatchery late-fall chinook salmon smolts. Data are from brood year 1993, but remain indicative of release length ranges and averages.

Table 10-14. Length ranges of naturally-produced chinook salmon and steelhead potentially co-occurring in Battle Creek and the Sacramento River with hatchery-origin late-fall chinook salmon during January.

	Fork Length (mm)	
Species / Run	Young-of-Year	Yearling
Fall Chinook[a]	0 - 50	202 - 270
Late-fall Chinook[a]	none	111 - 246
Spring Chinook[a]	41 - 67	202 - 270
Winter Chinook[a]	55 - 135	none
Steelhead[b]	none	140 - 200

a Length ranges for natural-origin chinook salmon were taken from a daily length increment table (Sheila Green, CA Department of Water Resources).

b Steelhead trout length ranges were back-calculated from scale analysis for upper Sacramento River *Onchorynchus mykiss* (CDFG, unpublished data).

High flows, high turbidity, and cool water temperatures associated with winter storm events (typical in northern California during January) create conditions both favorable for rapid downstream emigration (Godin 1981) and unfavorable for foraging (Gregory and Levings 1998) by late-fall chinook from Coleman NFH. Water temperatures in Battle Creek and the Sacramento River are commonly below 10 °C during January, reducing the metabolic requirements of predators and consequently reducing consumption by hatchery-origin late-fall chinook salmon. Sacramento River flows during January are highly variable and erratic depending on precipitation events (Figure 10-8). Dramatic increases of flow in the Sacramento River are usually accompanied by elevated turbidity (Figure 10-9). Migration of juvenile salmonids is commonly associated with floods and increased water turbidity which reduce underwater light transmission (see review in Godin 1981). The strong tendency of salmonid juveniles to emigrate during periods of high flow and turbidity has been considered an antipredator adaptation.

Hatchery-origin late-fall chinook salmon released from Coleman NFH exhibit rapid emigration from the upper Sacramento River. Downstream monitoring conducted during 1993 showed that the majority of hatchery-origin late-fall chinook smolts emigrated past GCID (RM 205) two days and Sherwood Harbor (RM 55) seven days following their release into Battle Creek (Service unpublished data, CDFG unpublished data). Monitoring efforts conducted at the RBDD during 1995 and 1996 show similar trends. During those years, approximately 50% of hatchery-origin late-fall chinook sampled were collected from two to six days following release into Battle

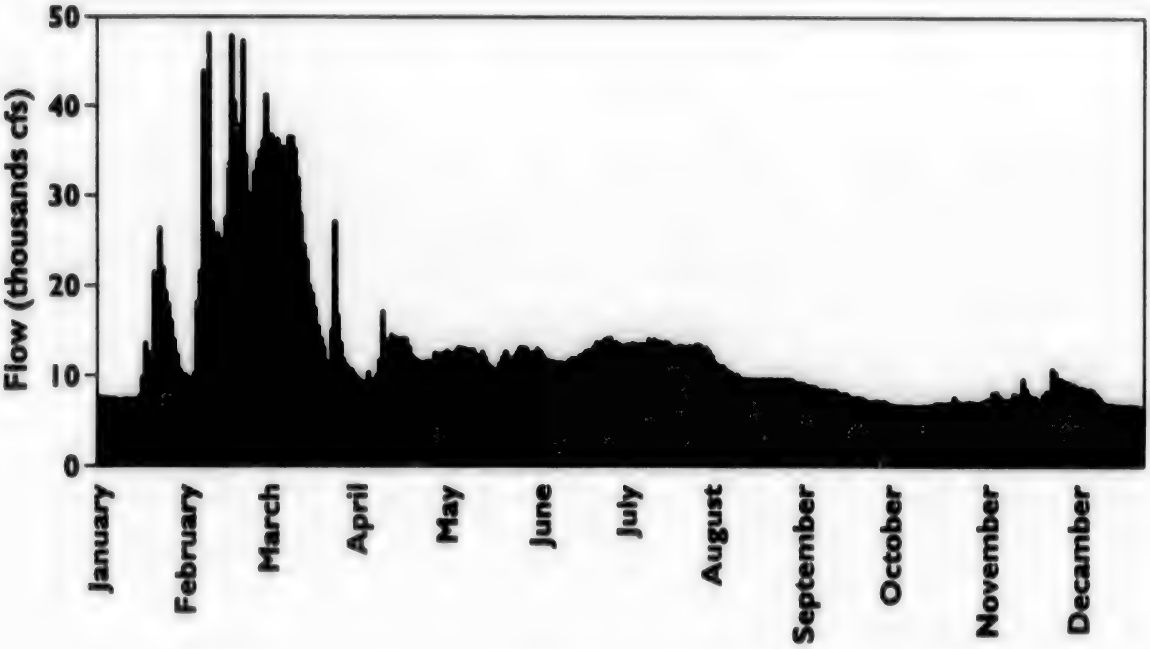

Figure 10-8. Hydrograph of average daily discharge in cubic feet per second (cfs) for the Sacramento River at Bend Bridge (river mile 258), 1999. Data are from the California Data Exchange Center (CDEC), March 5, 2000.

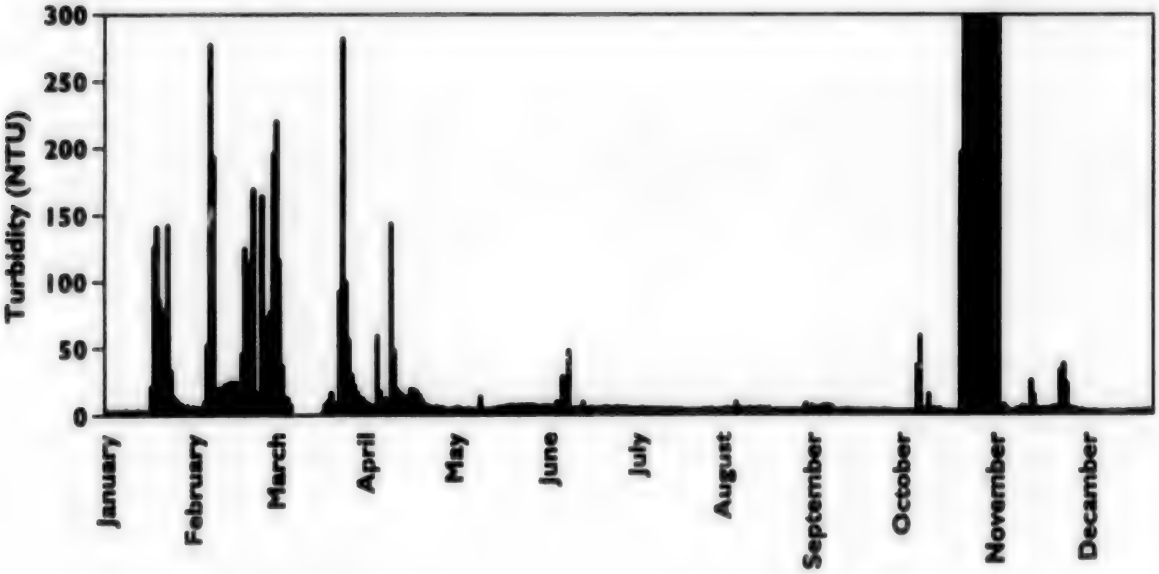

Figure 10-9. Average daily turbidity in nephelometric turbidity units (NTU) for the Sacramento River at Bend Bridge (river mile 258), 1999. Data are from the California Data Exchange Center (CDEC), March 5, 2000.

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Creek. These data demonstrate a rapid emigration by hatchery-origin late-fall chinook salmon released into Battle Creek during January, equal to more than 30 miles per day (USFWS, RBFWO unpublished data).

Competition/Displacement
Ecological risks of competition/displacement occurring as a result of releasing hatchery-origin late-fall chinook salmon are considered to be low. Interactions between hatchery-origin late-fall chinook and natural salmonid stocks are minimized by the following factors: 1) late-fall chinook are released when they are smolting, encouraging rapid emigration from freshwater environments and low levels of delayed migration; 2) late-fall chinook are released at times of high river discharge and turbidity, resulting in rapid downstream travel; and, 3) to attain a rapid rate of emigration, late-fall chinook likely congregate in areas of high velocity, resulting in a large degree of segregation from salmonids rearing for extended durations. Data from other areas indicate that salmon released as smolts compete minimally if they migrate without delay (Stewart and Bjornn 1990).

Disease Transmission
Hatchery-origin late-fall chinook salmon are released as smolts. Late-fall chinook smolts emigrate rapidly and en-masse from the upper Sacramento River, reducing the amount of temporal and spatial overlap with natural salmonid populations in the freshwater environment. To sustain this rapid rate of emigration, hatchery-origin fall chinook likely congregate in swiftly-flowing sections of the river, unlike newly-emergent natural-origin late-fall chinook and steelhead which tend to seek refuge at the river margins for extended rearing. Because hatchery-origin late-fall chinook do not generally rear for extended duration in Battle Creek or the upper Sacramento River, the potential for disease transmission to natural populations in the river environment is reduced. In addition, the new ozone water disinfection system at Coleman NFH is expected to largely ameliorate concerns of disease both on-station and after release.

10.10 Analysis of risks resulting from releases of hatchery-origin winter chinook salmon

A summary of impacts to natural salmonid populations resulting from releases of juvenile winter chinook salmon from Livingston Stone NFH is presented in Table 10-15. Detailed explanations follow.

Winter chinook salmon pre-smolts are released from Livingston Stone NFH during late-January. Juveniles are transported at dusk from the hatchery to the Sacramento River at Caldwell Park, Redding (RM 299) where they are liberated near suitable rearing habitats. The number of winter chinook released depends largely upon the number of winter chinook adults collected and spawned at the hatchery and survival of artificially propagated juveniles. Total releases of winter chinook salmon may approach 200,000 annually.

Winter chinook salmon are at critically low levels of abundance. The goal of the winter chinook propagation program at Livingston Stone NFH is to supplement naturally produced winter chinook salmon in the upper Sacramento River, leading to recovery and de-listing of that

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population. Both hatchery- and natural-origin winter chinook salmon are listed as endangered under the ESA. Because the winter chinook propagation program at Livingston Stone NFH is designed to supplement the only endangered salmonid population in the Central Valley, and because both hatchery and natural populations are listed as endangered under the ESA, we consider potential impacts of releasing hatchery-origin winter chinook juveniles only in regard to the natural population of winter chinook salmon. Detrimental effects to other races of salmon are unlikely, however, because of the low number of winter chinook juveniles released annually from Livingston Stone NFH.

Table 10-15. Summary of impacts to natural salmonid populations resulting from releases of juvenile winter chinook salmon from Livingston Stone National Fish Hatchery. See text (Section 10.6) for definitions of impact ratings and descriptions of criteria.

	Impact Rating					
	Battle Creek			ESU		
Natural-Origin Species / Run	Predation	Competition / Displacement	Disease	Predation	Competition / Displacement	Disease
Fall Chinook	N.A.	N.A.	N.A.	None	None	None
Late-fall Chinook	N.A.	N.A.	N.A.	None	None	None
Winter Chinook	N.A.	N.A.	N.A.	None	None	None
Spring Chinook	N.A.	N.A.	N.A.	None	None	None
Steelhead	N.A.	N.A.	N.A.	None	None	None

Predation

The average size of hatchery-origin winter chinook pre-salmon smolts at the time of release in January is 80 - 90 mm, with an approximate range of 40 to 120 mm (Figure 10-10). Naturally produced winter chinook salmon potentially co-occurring with hatchery-origin winter chinook (after their release) salmon range in size from 55 to 135 mm (Daily length increment chart, Sheila Green, California Department of Water Resources {DWR}, Sacramento). Because hatchery- and natural-origin winter chinook salmon are approximately equal in size during their co-residence in the Sacramento River, predatory interactions are unlikely.

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Competition/Displacement
An objective of the winter chinook salmon propagation program is that hatchery-released pre-smolts integrate with the naturally produced winter chinook population in the Sacramento River. Negative effects of competition/displacement between hatchery and natural populations of winter chinook salmon are not likely to occur because: 1) rearing habitats in the upper Sacramento River are not considered to be a factor limiting the abundance of winter chinook salmon; 2) hatchery- and natural-origin winter chinook salmon are of similar size at the time of the hatchery release; and, 3) naturally-produced winter chinook have established home-territories prior to the release of hatchery fish.

Currently, rearing habitats of winter chinook salmon in the upper Sacramento River are presumed to be used below their carrying capacity. Natural production of winter chinook smolts during recent years has been substantially lower than historic levels, with smolt production from 1988 through 1992 estimated at about 117,000[5] annually. Although information on winter chinook rearing capacity is lacking, the Sacramento River likely has the capacity to rear substantially more winter chinook juveniles than it currently supports. If a limited number of agonistic interactions occur between similarly sized hatchery- and natural-origin winter chinook salmon, naturally-produced winter chinook salmon may have a competitive advantage since they would have established feeding territories.

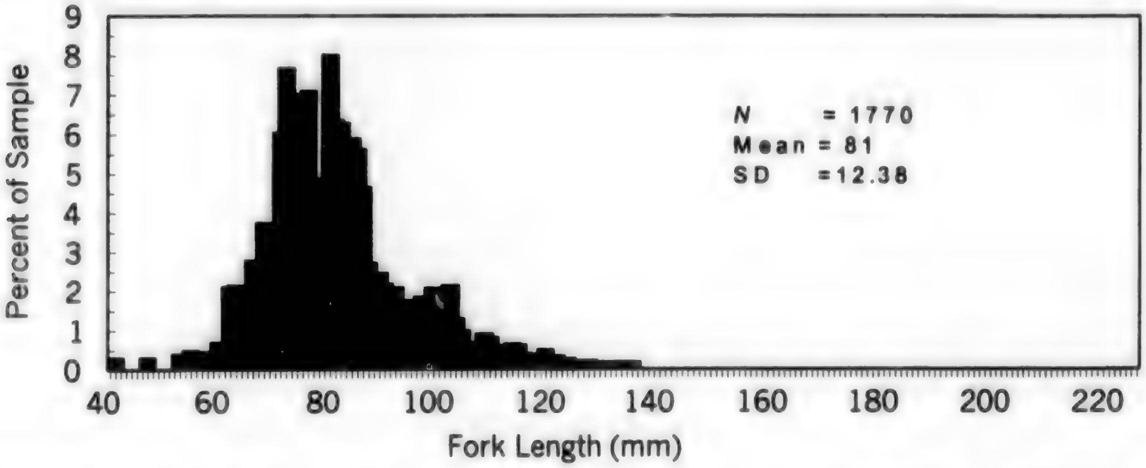

Figure 10-10. Length frequency distribution of Livingston Stone winter chinook salmon smolts. Data are from brood year 1993, but remain indicative of release length ranges and averages.

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[5] Winter chinook smolt production for years1988 - 1992 was estimated using sex-ratio and run-size counts from the RBDD fish ladders, fecundity data from Coleman NFH, and an estimated egg-to-smolt survival rate of 10%.

Disease Transmission
Increased transmission of disease is not expected to result from releasing hatchery-origin winter chinook salmon from Livingston Stone NFH. It is assumed that hatchery-origin winter chinook salmon pre-smolts integrate with naturally produced winter chinook salmon in the Sacramento River. These stocks likely co-exist in similar habitats and in close proximity to one another in river environments. Therefore, disease transmission from hatchery fish could be a major concern if the hatchery-released infected juveniles during an epizootic event. However, winter chinook juveniles from Livingston Stone NFH have been notably healthy and free of disease problems. There have been no outbreaks of IHNV or BKD at Livingston Stone NFH, nor has rosette agent been found in any adults or juveniles at the facility. Lack of disease outbreaks at Livingston Stone NFH can be attributed to effective prophylactic treatments, good fish culture practices, and the anadromous-free water supply from Shasta Lake.

10.11 Analysis of risks resulting from releases of hatchery-origin steelhead trout

Approximately 600,000 steelhead smolts are released from Coleman NFH in January at the Sacramento River at Bend Bridge[6] (RM 258). Steelhead are trucked to the release site using the hatchery's two fish distribution vehicles. In the past, up to 150,000 of the total steelhead production from the hatchery's pre-release pond were released directly into Battle Creek at the hatchery. Beginning with brood year 2000, however, hatchery personnel will collect and transport nearly all hatchery-produced steelhead to the Sacramento River release location. A small number of steelhead, perhaps 1-10,000, may need to be released into Battle Creek if they cannot be collected for transport.

A summary of impacts to natural salmonid populations resulting from releases of steelhead trout from Coleman NFH is presented in Table 10-16. Detailed explanations follow.

Nearly all juvenile steelhead produced at Coleman NFH will be released 13-miles downstream of Battle Creek in the Sacramento River; therefore, juvenile steelhead releases are not expected to impact Battle Creek. However, interactions between salmonids from Coleman NFH and naturally produced salmonids in the Sacramento River are potentially greatest for hatchery-origin steelhead, because of their comparatively larger body size, a general tendency for piscivory at the time of release, and a proclivity for adopting alternate life-history patterns (e.g., residualization).

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[6] Steelhead trout from Coleman NFH have been released at Bend Bridge since brood year 1999. The previous release site at Balls Ferry Bridge (RM 276) was abandoned due to concerns of increased mortality of released fish due to boat traffic and concerns of potential predation by steelhead upon newly-emerged fall chinook salmon. Changing the release site to Bend Bridge may benefit fall chinook salmon emerging from the local congregation of redds typically located near the former release location at Balls Ferry.

Table 10-16. Summary of impacts to natural salmonid populations resulting from releases of juvenile steelhead from Coleman National Fish Hatchery. See text (Section 10.6) for definitions of impact ratings and descriptions of criteria.

	Impact Rating					
	Battle Creek			ESU		
Natural-Origin Species / Run	Predation	Competition / Displacement	Disease	Predation	Competition / Displacement	Disease
Fall Chinook	None	None	None	Moderate	Low	None
Late-fall Chinook	None	None	None	Low	Low	None
Winter Chinook	None	None	None	Low	Low	None
Spring Chinook	None	None	None	Low	Low	None
Steelhead	None	None	None	Low	Low	None

Predation

Yearling steelhead smolts average 195 mm (range 100 - 300 mm) at the time of release from Coleman NFH. The size ranges of naturally-produced chinook salmon and steelhead potentially co-occurring with hatchery-origin steelhead in the Sacramento River are shown in Table 10-17. Based on the size of hatchery-released steelhead, size ranges of naturally produced salmonid stocks, and predator-prey size constraints (i.e., prey ≤ ⅓ of predator length), hatchery-origin steelhead could potentially capture and consume YOY fall, spring, and winter chinook juveniles. Although hatchery-origin steelhead juveniles could potentially capture and consume spring and winter chinook juveniles, impacts to spring and winter chinook are likely minimal. During January when steelhead are released from Coleman NFH, millions of fall chinook salmon are just beginning to emerge from the gravels (Johnson et al. 1992). Steelhead are opportunistic feeders, and are therefore more likely to prey on the abundant and less-agile newly-emerged fall chinook fry than the larger and less abundant winter and spring chinook salmon. Menchen (1981) examined the stomach contents of 910 yearling steelhead released in Battle Creek and found 103 stomachs contained a total of 1,125 emergent fall chinook fry. Chinook salmon of other races were not detected as being consumed by hatchery-origin steelhead in that investigation. Hallock (1989) sampled the stomach contents of yearling steelhead trout released into Battle Creek in February and March 1975 and found an average of 1.4 fall chinook salmon per steelhead stomach.

Environmental conditions in the Sacramento River likely reduce predation on natural-origin salmonids by hatchery-origin steelhead. Steelhead and late-fall chinook salmon are both released from Coleman NFH during early-January. During January in northern California, high flows,

Table 10-17. Length ranges of naturally-produced chinook salmon and steelhead potentially co-occurring in the Sacramento River with hatchery-origin steelhead following their release in January.

	Fork Length (mm)	
Species / Run	Young-of-Year	Yearling
Fall Chinook[a]	0 - 50	202 - 270
Late-fall Chinook[a]	none	111 - 246
Spring Chinook[a]	41 - 67	202 - 270
Winter Chinook[a]	55 - 135	none
Steelhead[b]	none	140 - 200

a Length ranges for natural-origin chinook salmon were taken from a daily length increment table (Sheila Green, CA Department of Water Resources).

b Steelhead trout length ranges were back-calculated from scale analysis for upper Sacramento River *Onchorynchus mykiss* (CDFG, unpublished data).

high turbidities, and cool water temperatures are typically associated with winter storm events. Winter storm events create conditions favorable for rapid downstream emigration (Godin 1981) but unfavorable for foraging (Gregory and Levings 1998). Water temperature in Battle Creek and the Sacramento River are commonly below 10 °C during January, reducing the metabolic requirements of predators, and likely reducing consumption by hatchery-origin steelhead. Flows and turbidities in the Sacramento River during January are highly variable and erratic depending on precipitation events (Figures 10-4 and 10-5). Migration of juvenile salmonids is commonly associated with floods and increased water turbidity which reduce underwater light transmission (see review in Godin 1981), interfering with the ability to see and identify prey. This is corroborated by Bigelow et al. (1995a). They examined stomach contents from 133 hatchery-origin steelhead trout captured in the Sacramento River and found no evidence of piscivory.

Residualization

Predation by hatchery-origin steelhead on natural-origin chinook salmon and steelhead could be substantial if a large number of hatchery-origin steelhead residualize. The size of steelhead smolts at release is known to effect the degree of residualism. Jonasson et al. (1994) and Whitsel et al. (1993) showed that the majority of residualized steelhead resulted from the smallest fish within a particular release group. Studies in the Snake River, Idaho showed that hatchery-origin steelhead less than 165 mm FL have a greater tendency to residualize (Bigelow et al. 1995b). Tipping et al. (1995) reported larger steelhead (>190 mm) emigrated at greater rates than smaller steelhead (< 190 mm). The majority of the steelhead released from Coleman NFH are greater than 190 mm. Of 500 fish sampled for pre-release length from brood year 1995, approximately 10% were less than 165 mm (USFWS, RBFWO, unpublished data).

Several studies have been conducted by the Service's Northern Central Valley Fish and Wildlife Office (now the Red Bluff Fish and Wildlife Office) to assess residualization of steelhead trout released from Coleman NFH. High levels of steelhead residualization at Coleman NFH have not been observed during any of these investigations. In the first study, sampling for steelhead released on January 27, 1993 in the upper Sacramento River produced no mainstem recaptures after February 17, three weeks after release (Bigelow et al. 1995a). Another investigation of steelhead residualization was conducted in 1994. In that study, 150,000 steelhead trout were released into Battle Creek during February 1994. Five post-release surveys, using four different sampling techniques, were conducted in Battle Creek between March 23 and September 28. No hatchery-origin steelhead trout were observed (USFWS 1995b). Recently, steelhead residualism was investigated using otolith microchemistry. During 1999, otoliths were sampled from adult steelhead returning to Coleman NFH and examined for concentrations of strontium indicative of ocean rearing. In that study, the vast majority of steelhead returning to Coleman NFH, and all steelhead greater than about 450 mm, were shown to be anadromous.

New information to indicate the extent of steelhead residualization should be forthcoming as a result of the basin-wide mass marking program. Beginning with brood year 1998, all steelhead smolts released from Coleman NFH have been mass marked with an adipose fin-clip. This marking program, combined with existing creel survey efforts by the CDFG and cooperation from local guides, should provide valuable information on steelhead residualization rates.

Competition/Displacement

A rapid emigration of hatchery-released steelhead smolts serves to reduce competition/ displacement of natural-origin salmonids. Competition by hatchery-origin salmonids is minimized if they migrate without delay (Stewart and Bjornn 1990). Rapid emigration of Coleman NFH steelhead is encouraged by: 1) releasing steelhead when they are smolting; and, 2) releasing steelhead at times of high river discharge and turbidity. Two groups of steelhead smolts released in January 1993 were recaptured at the Glen-Colusa Irrigation District (GCID) diversion (RM 206) 22 and 5 days post-release (Bigelow et al. 1995a). Differing rates of emigration observed in that investigation were apparently affected by prevailing flow conditions. Steelhead released from Coleman NFH on January 8, 1996 were sampled emigrating past the RBDD primarily on January 16 (8-days post-release), translating to an emigration rate of approximately four miles per day. Similar emigration patterns of hatchery-origin steelhead from Coleman NFH have been documented through rotary screw trap monitoring at RBDD for brood year 1996 through 1998 (USFWS, RBFWO unpublished data).

Disease Transmission

Hatchery-origin steelhead are released as smolts. Steelhead smolts from Coleman NFH emigrate rapidly and en-masse from the upper Sacramento River, reducing the amount of temporal and spatial overlap with natural salmonid populations in the freshwater environment. The January release of steelhead is commonly associated with high flow and high turbidity events, which further promote rapid emigration through the Sacramento River. Because hatchery-origin steelhead do not generally rear for an extended duration in the upper Sacramento River, the potential for disease transmission to natural populations is reduced. The new ozone water disinfection system at Coleman NFH is expected to largely ameliorate concerns of disease both on-station and after release.

10.12 Other potential risks to natural salmonid populations from hatchery releases

Several other potential risks to natural populations from hatchery releases have been identified, including: interactions between hatchery and natural populations in estuarine and ocean environments, possible alterations in migratory behavior of natural fish triggered by large numbers of outmigrating hatchery fish, and increases in straying when hatchery fish are released off-site.

Potential Risks from Interactions in Estuarine and Ocean Environments

We have not attempted to determine potential negative impacts in ocean environments resulting from hatchery releases. Scientific information is particularly sparse regarding interactions between hatchery and natural salmonids occurring in estuarine and ocean environments. Recent analyses suggest variation in survival of salmon in the ocean is probably related to cycles of ocean productivity (Hare et al. 1999). However, it is not currently possible to determine the carrying capacity for chinook salmon and steelhead trout in ocean environments. Neither is it possible to determine whether density-dependent factors resulting from hatchery propagation might decrease survival rates of naturally produced salmonids.

Potential Risks of Altered Migratory Behavior (i.e, Pied Piper Effect)

We were also unable to assess potential negative effects from altered migratory behavior that may be caused by hatchery releases (i.e., the pied piper effect). Releases of large numbers of hatchery-origin juveniles from Coleman NFH have the potential to alter the migratory patterns of juvenile natural-origin salmonids in the Sacramento River. Alteration of migratory patterns may impact natural fish by subjecting them to undue predation or by promoting premature entrance into saltwater (i.e., if the fish is not physiologically ready). However, large scale releases from Coleman NFH are often afforded protective measures (e.g., pulse flows, assured passage through RBDD, closure of Delta Cross Channel gates) to facilitate downstream migration. Naturally produced salmonids which outmigrate with hatchery-origin salmon while protective measures are in place may benefit from a survival advantage. Currently, few data are available to indicate that altered migration occurs, and little is known about potential negative effects to natural populations that may result from altered migratory patterns. .

Potential Risks from Straying of Hatchery-origin Salmonids

Stray rates in natural salmonids have been reported to range from <1% to 25% (Shapovalov and Taft 1954, Quinn et al. 1987, Labelle 1992). Previous analyses of stray rates of general production releases of chinook salmon (i.e., salmon released into Battle Creek or the upper Sacramento River) suggest they are not zero, but are likely no greater than 10% (Sholes and Hallock 1979, Cramer 1991). Stray rates for steelhead trout are not available; however, similarities between rearing and release strategies for chinook salmon and steelhead trout raised at Coleman NFH suggest that steelhead trout raised at Coleman NFH probably experience a stray rate similar to those expected for late-fall chinook salmon. These similarities include long-term rearing on-site (usually around a year) and release locations that are close to the return site (Battle Creek). The Service believes that the current rearing and release practices for general production chinook salmon and steelhead trout reduce straying to background rates associated with adaptive traits common to all populations of chinook salmon. Genetic impacts from these inherent (i.e., background) stray rates are thought to be minimal since all stocks propagated at Coleman and Livingston Stone NFH's are considered within the ESU's of the natural stocks, and natural adults are incorporated as hatchery broodstock.

Since as much as half of the late-fall chinook salmon produced at Coleman NFH may be released as off-site experimental releases, potential risks from straying are greater for late-fall chinook. To analyze potential risks associated with these experimental releases, we analyzed stray rates of off-site releases compared to background rates (on-site releases). Our analyses of stray rates for off-site releases of chinook salmon indicate that: 1) off-site releases may disrupt the imprinting cycle; 2) straying by juveniles released off-site can be substantial (70-90%); and, 3) straying typically increases as the distance from the hatchery to the off-site release location is increased. Furthermore, previous investigations by the Service's RBFWO show that the geographic distribution of straying increased as the distance to off-site release locations increases (USFWS 1996c). The agencies or organizations proposing these experimental releases must obtain approval from the appropriate regulatory agencies (e.g., NMFS, CDFG) prior to the release. The risks associated with these experimental releases need to be weighed continually against the benefits of the information obtained by the agencies and organization proposing and approving these studies. See Appendix 10C for our analysis of stray rates and a discussion of the potential genetic impacts of straying.

MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

11.1 Monitoring and evaluation of performance indicators

Monitoring and evaluation of hatchery programs at Coleman and Livingston Stone NFH's are integral components of the Service's high priority program to restore upper Sacramento River stocks of chinook salmon and steelhead trout. Most activities involving monitoring and evaluating Coleman and Livingston Stone NFH's are coordinated out of the Service's Red Bluff Fish and Wildlife Office (RBFWO). Monitoring and evaluation activities related to fish health concerns are conducted primarily by the CA-NV FHC.

The two overall goals of the hatchery evaluation program are: 1) assisting the hatchery to maximize contributions to commercial and sport fisheries, and/or escapement to the upper Sacramento River (consistent with the facility's mitigation responsibility for the Central Valley Project); and 2) collecting and analyzing data to assess potential impacts of propagation programs on naturally produced salmonids and recommend changes to propagation strategies to minimize or eliminate suspected impacts.

Much of the evaluation work is dependent on marking and tagging juvenile salmon and steelhead prior to release from the hatchery (contribution rate estimation and hatchery/natural stock interactions) and subsequently recovery of marked fish returning as adults. Approximately eleven evaluations/studies are currently underway including the four general contribution evaluations for the fall, late-fall, and winter chinook salmon and steelhead trout production programs at Coleman or Livingston Stone NFH's. These evaluations currently require tagging or marking of approximately 2.5 million hatchery-origin juvenile salmonids annually. Recovery of marked adults both at Coleman NFH and in the field (Battle Creek and Sacramento River) is conducted by personnel from RBFWO, CDFG, DWR, USBR and private citizens.

Other primary functions of the RBFWO's Hatchery Evaluation program include the following:

- Compile, summarize and distribute information pertaining to hatchery releases, adult returns and mark recoveries
- Serve as principle liaison between the hatchery and other agencies / interested parties (i.e., National Marine Fisheries Service, California Department of Fish and Game, etc.)
- Preparing documentation to fulfill ESA, NEPA, and CESA requirements necessary to conduct propagation programs for listed and non-listed species. (Environmental Assessments, Biological Assessments, Section 10 enhancement permits, etc.)
- Collect and track tissue samples (primarily that of endangered winter chinook salmon) to assist in the assessment of the genetic impacts of the winter chinook salmon propagation programs

The following monitoring and evaluation activities will be conducted to measure performance of artificial propagation programs at Coleman and Livingston Stone NFH's. Data resulting from these monitoring efforts will be used to adaptively manage the hatchery programs to maximize benefits and minimize potential risks resulting from artificial propagation programs at Coleman and Livingston Stone NFH's.

11.2 Performance indicators addressing benefits

Performance Standard B1: Optimize abundance of anadromous salmonids in Battle Creek by integrating Coleman NFH with Battle Creek Restoration (FCS, LFCS, STT)

Monitoring and Evaluation:

- Continue to monitor numbers of hatchery- and natural-origin adults during spawning operations
- Continue to acquire and analyze CDFG run-size estimates at the Red Bluff Diversion Dam (RBDD), and in lower Battle Creek
- Continue to conduct Service video monitoring and adult trapping at the Coleman NFH barrier weir to enumerate passage of hatchery- and natural-origin adults from early-March through September 1
- Continue other Service monitoring programs in Battle Creek (e.g., juvenile emigration monitoring) to assess current and future levels of natural production within Battle Creek

Performance Standard B2: Increase or maintain harvest opportunities for commercial and sport fisheries (FCS, LFCS, STT)

Monitoring and Evaluation:

- Continue to mark and tag all, or representative portions, of each stock produced at Coleman and Livingston Stone NFH's
- Conduct on-site bio-sampling (tag recovery and measuring biological characteristics) of all marked adults returning to Coleman NFH
- Estimate contribution (rates and total numbers) of Coleman NFH fall and late-fall chinook salmon to Pacific Ocean commercial and sport fisheries and the Sacramento River sport fishery
- Monitor fishery contribution of Coleman NFH fall and late-fall chinook salmon as a proportion of the Central Valley Abundance Index (ocean harvest plus river escapement) as reported by Pacific Fishery Management Council (PFMC 1999)
- Estimate sport harvest of Coleman NFH fall and late-fall chinook salmon in the Sacramento River based on CDFG creel survey data
- Monitor ocean contribution rates of hatchery-origin winter chinook salmon as an index of harvest on naturally-produced winter chinook salmon

Performance Standard B3: Assist in the restoration of listed stocks of anadromous salmonids (WCS, STT)

Monitoring and Evaluation:

- Continue to conduct field surveys to generate adult run-size estimates and evaluate survival, spawning success, and integration of hatchery propagated winter chinook salmon with the natural population
- Monitor and evaluate genetic risks of the winter chinook propagation program (calculate effective population size {N_e} annually at time of hatchery release) to measure potential genetic effects on the natural population
- Evaluate effectiveness of the winter chinook salmon propagation program at Livingston Stone NFH for assisting restoration by comparing estimates of replacement rates for hatchery propagated fish to estimated replacement rates for naturally produced fish. It is assumed that the winter chinook salmon hatchery propagation program benefits restoration goals when hatchery:natural replacement rates are equal to or greater than 1.0
- Use juvenile emigration data (e.g., abundance, life stage, timing) collected by rotary screw trapping to assess the effectiveness of steelhead trout adult relocations in upper Battle Creek.
- Monitor adult steelhead returning to Coleman NFH and passing the barrier weir to document changes in abundance of naturally-produced steelhead in the system

Performance Standard B4: Create a genetic reserve for an endangered species through a captive broodstock program (WCS)

Monitoring and Evaluation:

- Monitor success at achieving maturation of captive broodstock at appropriate age and time
- Collect viable gametes from mature captive broodstock at appropriate age, size, and time

Performance Standard B5: Maintain stock integrity and conserve genetic and life history diversity (WCS, FCS, LFCS, STT)

Monitoring and Evaluation:

- At the conclusion of each spawning season, analyze CWT's from spawned fish to verify selection of target broodstock
- Analyze trends in fecundity, survival for different life stages, return rates, return timing, spawn timing, adult size and age composition, and other parameters as surrogates for measures of "fitness" of the hatchery stock

Performance Standard B6: Provide fish for experimental purposes (WCS, FCS, LFCS, STT)

Monitoring and Evaluation:

- Evaluate requests for hatchery-origin fish and determine participation in experimental investigations

Performance Standard B7: Conduct research to monitor and evaluate hatchery operations and practices (WCS, FCS, LFCS, STT)

Monitoring and Evaluation:

- Evaluate contribution of fall and late-fall chinook salmon to ocean fisheries
- Continue mark screening and mark/tag recovery efforts on adults returning to Coleman NFH, the Keswick Dam Fish Trap, and the RBDD
- Continue to collect and analyze information obtained through adult trapping and video monitoring at the Coleman NFH barrier weir in Battle Creek
- Summarize and analyze ocean harvest data (Pacific States Marine Fisheries Commission)
- Summarize and analyze information collected during Battle Creek and mainstem Sacramento River adult carcass surveys
- Analyze information collected from juvenile emigration monitoring programs on Battle Creek and the Sacramento River

Performance Standard B8: Improve survival of propagated species/stock using appropriate incubation, rearing, and release strategies (WCS, FCS, LFCS, STT)

Monitoring and Evaluation:

- Analyze trends in survival for different life stages at the hatchery
- Analyze trends in ocean and freshwater harvest rates and escapement

Performance Standard B9: Improve survival by preventing disease introduction, spread, or amplification (WCS, FCS, LFCS, STT)

Monitoring and Evaluation:

- Analyze survival trends for different life stages at the hatcheries
- Examine trends of ocean harvest, freshwater harvest, and hatchery escapement in regards to documented history of disease incidence at Coleman NFH and Livingston Stone NFH
- Examine on-station mortality of chinook salmon and steelhead trout as percent of total production

Performance Standard B10: Provide local, state, and regional economic enhancement (FCS, LFCS, STT)

Monitoring and Evaluation:

- Estimate direct and indirect economic enhancement of local, state, and regional economies resulting from propagation programs at Coleman NFH by calculating input to local economy and commercial and sport value of the fishery attributable to the hatchery. Due to the difficulty involved with this task, we do not propose to accomplish this on an annual basis.

11.3 Performance Indicators addressing risks

Performance Standard R1: Minimize potential negative effects of Coleman NFH on restoration of Battle Creek (FCS, LFCS, STT)

Monitoring and Evaluation:

- Analyze natural production of Battle Creek below and above the hatchery barrier weir
- Monitor emigration of hatchery releases to document rapid movement
- Monitor quality of effluent water from Coleman NFH

Performance Standard R2: Minimize potential interactions between hatchery- and natural-origin stocks (FCS, LFCS, WCS, STT)

Monitoring and Evaluation:

- Analyze stray rates of fall and late-fall chinook salmon, comparing groups released at different sizes and at different locations (see straying section of this document)
- Analyze emigration rates and timing of hatchery- and natural-origin chinook salmon and steelhead trout (see juvenile release section of this document)

Performance Standard R3: Do not introduce, spread, or amplify pathogens of natural stocks (FCS, LFCS, WCS, STT)

Monitoring and Evaluation:

- Examine trends of ocean harvest, freshwater harvest, and hatchery escapement in regards to documented history of disease incidence at Coleman NFH and Livingston Stone NFH
- Examine on-station mortality of chinook salmon and steelhead trout as proportion of total production

Performance Standard R4: Minimize the potential for negative genetic effects of artificial propagation programs on natural stocks (FCS, LFCS, WCS, STT)

Monitoring and Evaluation:

- Analyze CWT's following each spawning season to verify selection of target broodstock
- Monitor and analyze trends in fecundity, survival for different life stages, return rates, return timing, spawn timing, adult size and age composition, and other parameters to indicate potentially deleterious changes occurring in the hatchery stock
- Calculate effective population size estimates for releases of winter chinook salmon
- Evaluate the effects of over-escapement on net production in Battle Creek by analyzing juvenile production estimates (see Section 3 on harvest)

Performance Standard R5: Do not exceed carrying capacity of fluvial, estuarine or ocean habitats (FCS, LFCS, WCS, STT)

Monitoring and Evaluation:

Freshwater - Evaluate emigration rates of hatchery-origin juveniles to verify rapid emigration
Estuarine - Limited data available
Ocean - Limited data available (see Harvest {Section 3} of this document)

Performance Standard R6: Conduct research to evaluate potential effects on natural stocks and adaptively manage hatchery operations and activities (FCS, LFCS, WCS, STT)

Monitoring and Evaluation:

- Depends on specific experimental designs
- Monitor emigration of juvenile salmonids originating naturally in Battle Creek above and below the barrier weir
- Monitor straying of fall and late-fall chinook salmon produced at Coleman NFH

RESEARCH

12.1 Investigation of interactions between hatchery- and naturally-produced juveniles

An ongoing study conducted by investigators from the Colorado State University will use fall chinook salmon from Coleman NFH to examine intraspecific competition among juvenile hatchery- and natural-origin chinook salmon in the Sacramento River. The study proposal and first progress report can be found in Attachments 12-1 and 12-2. Principal investigators are Ed Weber and Dr. Kurt Fausch. Funding for the study is provided by the U.S. Bureau of Reclamation. The overall goal of the study is to evaluate the existence and relative intensity of competition among hatchery-reared and naturally spawned fall chinook salmon. The following specific objectives will be investigated: 1) determine the patterns of hatchery fish outmigration; 2) determine if hatchery fish displace natural fish; and, 3) determine the existence of competition among hatchery fish that delay emigration.

12.2 Studies associated with monitoring the winter chinook propagation program

The Service's RBFWO cooperates with the CDFG on a winter chinook salmon escapement survey to generate an estimate of winter chinook abundance and monitor the effectiveness of the winter chinook propagation program. A CALFED research proposal is included as Attachment 12-3. The survey has recently received funding through 2003. Take of ESA-listed species associated with this survey is covered through July 2001 under the Services section 10 enhancement permit.

12.3 Studies associated with monitoring the Battle Creek Restoration Process

The Service's RBFWO will coordinate and conduct monitoring activities associated with assessing progress toward Battle Creek restoration. Planned monitoring activities include videotaping and trapping adults as they pass through the upstream fish ladder in the Coleman barrier weir. These projects are currently funded by CALFED grant. Take associated with Battle Creek monitoring activities is covered under the Services recently submitted section 10 research permit.

13 CITATIONS, APPENDICES AND ATTACHMENTS

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13.2 Appendices

Appendix 1A. Historic impacts and mitigation attempts for spring chinook salmon.

There is no shortage of information suggesting spring chinook salmon have been heavily impacted by dam construction and water diversions. From 1900 to 1930 hydroelectric development and irrigation projects truncated large portions of the headwaters of most Central Valley rivers by dam construction. By 1928, Clark (1929) estimated only 510 lineal miles remained of the original 6,000 miles of spring chinook salmon habitat (an 80% reduction of principally spring chinook salmon spawning area). For example, in Battle Creek, salmon spawning habitat was significantly impacted in the early 1900's by a series of dams, diversions and canals constructed by Pacific Gas and Electric (PG&E) for hydroelectric power generation (Clark 1929, Richardson 1987). These structures adversely impacted salmon migration by blocking access and reducing flows, so that, even with fish ladders, salmon were unable to migrate upstream (Clark 1929). Clark (1929) and Hanson et al. (1940) suggest spring chinook were the most severely impacted in Battle Creek due to the hydroelectric power development and were largely extirpated from the system by 1928 (Clark 1929). With the completion of Friant Dam in 1942, spring chinook salmon were eliminated from the San Joaquin drainage. Simultaneously, Shasta Dam eliminated about 200 additional miles of chinook salmon spawning habitat, including nearly all of the winter chinook salmon spawning habitat (Fisher 1994).

The construction of Shasta and Keswick dams were likely to impact fall and spring chinook salmon by blocking migration to historic spawning areas. Salmon runs occurred extensively in the various river reaches that were blocked by Shasta and Keswick Dams (Richardson 1987). These reaches included the Little Sacramento River, the Pit River and its tributaries and the McCloud River. The primary run ascending the river to the headwaters of the Little Sacramento, McCloud River, Hat Creek and even Fall River (on the upper Pit River) was spring chinook (Rutter 1903). Unlike spring chinook salmon, fall chinook did not ascend to the headwaters of these rivers, and the river reach from Redding to Tehama was noted as an important spawning area for fall chinook salmon (Rutter 1903). However, fall chinook salmon were known to spawn historically up to 1,000 ft elevations and the fall run was impacted by the construction of Shasta Dam (Yoshiyama et al. 1998; Fisher 1994).

The Shasta Salvage Plan to mitigate for the construction of Shasta Dam was quite extensive and included mitigation efforts for spring and fall chinook salmon. Coleman National Fish Hatchery (NFH) was constructed as part of the Shasta Salvage Plan, to partially mitigate for losses to anadromous salmonid spawning and rearing habitat resulting from the construction of Shasta Dam. One of the conclusions drawn by the Board of Consultants while developing the plan was, of the salmon arriving in the Redding area and therefore likely to be impacted by the construction of Keswick and Shasta Dams, approximately 75% were assumed to be fall chinook salmon while the remaining 25% were assumed to be spring chinook salmon (Richardson 1987). Components of the adopted salvage plan included the following: 1) transfer of spring chinook salmon from the mainstem Sacramento River to Coleman NFH for spawning, 2) relocation of spring chinook salmon from the mainstem to Deer Creek, 3) transfer of early fall chinook salmon from the mainstem Sacramento River to Coleman NFH, 4) holding of fall chinook salmon between racks for natural spawning, 5) construction of trapping facilities in Keswick Dam and Balls ferry racks, 6) three racks in the Sacramento River, 7) a rack in Deer Creek, 8) seven tank trucks for fish transportation, 9) construction of Coleman NFH, and 10) a fish ladder around the lower falls in Deer Creek. Another component of the plan which appears never to have been implemented, was to haul spring chinook salmon to Darrah Springs Hatchery on Battle Creek as part of an artificial propagation program at that facility (Richardson 1987) .

Many of the components of the Shasta Salvage Plan failed. Attempts to install the racks in the Sacramento River were abandoned in 1946 after repeated wash outs, and relocation and artificial propagation efforts for spring chinook salmon were not successful. High prespawning mortality was incurred for spring chinook relocated to Deer Creek and relocation to that creek was discontinued after a few short years. Spring chinook were propagated at Coleman NFH between 1943 and 1951 (except for 1948; Coleman NFH Annual Report 1948). From its inception, the spring chinook propagation program at Coleman NFH met with minimal success. High summer water temperatures caused high pre-spawning mortality (e.g., 42% in 1947; Coleman NFH Annual Report 1947) for spring chinook broodstock. (Luken et al. 1981). In addition, numbers of adult spring chinook returning to Battle Creek decreased dramatically, with so few adults returning in 1948 that no eggs were taken (Coleman NFH Annual Report 1948, Luken et al. 1981). Due to the high mortality associated with relocation and unsuccessful propagation attempts, Moffett (1949) recommended that the population of spring chinook salmon may fair better if left undisturbed in the Sacramento River. Therefore, all attempts to relocate or establish a rearing program for spring chinook salmon were abandoned by 1951.

Future mitigation efforts for spring chinook salmon are under examination. In 1999 the U.S. Fish and Wildlife Service initiated a Re-evaluation process to comprehensively review fish production programs and other actions associated with the operation of Coleman and Livingston Stone National Fish Hatcheries. One of the Hatchery Management Alternatives that surfaced during that process was the option of a renewed effort for a spring chinook salmon propagation program. All alternatives developed during the Re-evaluation process are currently being analyzed, and final conclusions will be available in late 2001.

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Appendix 2A. False-attraction, or "decoying," of naturally-produced salmon into Battle Creek

In this section we analyze the hypothesis that large numbers of naturally-produced fall chinook salmon adults may be falsely-attracted into Battle Creek, lured by large congregations of spawning adults in the lower sections of that tributary. False attraction, or "decoying," has been theorized to potentially occur during recent years as a result of very large escapements of predominantly hatchery-origin fall chinook salmon to Battle Creek and dramatically lower escapements of predominantly natural-origin fall chinook salmon to the upper Sacramento River. According to the decoy hypothesis, pheromones, gametes, and spawning activity produced by large congregations of adults may falsely-attract natural origin salmon from the Sacramento River. Furthermore, spawning success and survivorship of decoyed fish and their progeny is believed to be reduced compared to natural spawners in the Sacramento River as a result of redd superimposition and decreased spawning success resulting from large congregations of adults.

Background:

Homing refers to the ability of maturing adult salmon and steelhead trout to return to, and spawn in, the particular stream or stream reach where they were born. The primary process enabling salmonids to home is olfactory recognition (Hasler and Scholz 1983, Healey 1991). Juvenile salmonids imprint on olfactory characteristics of their natal stream or stream reach, particularly organic compounds derived from soils and vegetation, and return to the location of their origin as adults by recognizing, or "remembering" the "scent." In addition to olfactory recognition, homing may also be influenced by factors such as genetics, flow, water temperature, habitat quality, and availability and suitability of alternate spawning areas. Furthermore, several researchers (see review in Hasler and Scholz 1983) have speculated that pheromones (sex hormones) emitted from conspecific juveniles or spawning adults may attract later-arriving migrants.

The pheromone-induced homing theory provides the basis for the false-attraction, or "decoying," hypothesis in Battle Creek, whereby natural-origin fall chinook salmon produced in the upper Sacramento River could potentially be attracted into Battle Creek by large congregations of spawning adults. Over-escapement of hatchery-origin fall chinook salmon adults during recent years has resulted in massive congregations at Coleman NFH and in lower Battle Creek. From 1995 through 2000, an average of approximately 92,000 fall chinook salmon returned to Battle Creek. The majority of fall chinook salmon entering Battle Creek during those years (average ≈ 60,000) did not enter the hatchery but, rather, remained in lower Battle Creek to spawn naturally. According to the decoy hypothesis, pheromones, gametes, and spawning activity produced by large congregations of adult fall chinook salmon in Battle Creek, predominantly of hatchery-origin, may falsely-attract naturally-produced salmon from the upper Sacramento River. Furthermore, it is hypothesized that, as a result of large over-escapement into Battle Creek and exceeding that stream's carrying capacity (K), survivorship and spawning success of decoyed fish are greatly reduced.

Cursory examination of mark-rates for fall chinook adults returning to Battle Creek during recent years *is* suggestive of considerable contribution resulting from naturally-produced fall chinook salmon. Recovery of marked (adipose fin-clipped) and coded-wire tagged (CWT) salmon sampled from Battle Creek and Coleman NFH during recent years shows that marked and tagged salmon comprise a lower proportion of the total Battle Creek population than would be expected solely from returns of fall chinook salmon produced at the hatchery. For example, fall chinook salmon smolts produced at Coleman NFH have been marked and coded-wire tagged at a rate of about 8% since 1995. Based on this information and an average 3-year life cycle for hatchery-origin fall chinook salmon, we would expect that adults returning to Coleman NFH since 1998 would also bear a mark rate of approximately 8%. However, during 1998, 1999, and 2000 complete census of fall chinook salmon encountered during spawning operations at Coleman NFH revealed mark rates of 4.9%, 6.0%, and 4.2%, respectively. These proportions are significantly lower than the proportion of juveniles marked at the hatchery (8%) and expected to return as adults to Battle Creek (Z test for equality of proportions; P(Z< 0.001) for each year). A lower-than-expected occurrence of marked fall chinook salmon adults returning to Battle Creek can best be explained to result from dilution of marked fish by added returns of unmarked (natural-origin) adults, above and beyond the initial proportion of unmarked fall chinook salmon released as smolts from Coleman NFH.

A lower-than-expected ratio of marked to unmarked fall chinook salmon adults returning to Battle Creek would likely result from an influx of naturally-produced (unmarked) fish originating in either: 1) the upper Sacramento River or another tributary; or, 2) Battle Creek. Dilution of marked returns to Battle Creek resulting from a substantial influx of naturally-produced adults originating in the upper Sacramento River or another tributary could signify false attraction, or "decoying." Alternatively, dilution of marked returns in Battle Creek may also result from substantial returns of fall chinook salmon spawned naturally in that tributary. In this case, returning adults would have homed accurately to their birthplace and therefore would not be considered to be decoyed into Battle Creek.

Obtaining direct scientific evidence to test the hypothesis of false-attraction (decoying) into Battle Creek is complicated by our inability to positively differentiate between naturally-produced adults born in Battle Creek from those born at other locations (e.g. the mainstem upper Sacramento River). However, an indirect analysis of the decoying hypothesis can be accomplished by utilizing coded-wire tagged groups of fall chinook salmon propagated at fish production facilities on the Feather, Merced, and Mokelumne rivers as surrogates for naturally-produced fall chinook salmon from the upper Sacramento River. Because fall chinook salmon produced at these facilities are generally released into the delta as juveniles, they exhibit an increased propensity to stray as adults as compared to releases made closer to the location of birth and rearing (see Appendix 3A on straying). During a typical year, several adults from these delta release groups stray into the upper Sacramento River and are sampled during routine monitoring activities. By looking at the way that these tagged adults, here-after referred to as "delta-strays," distribute themselves geographically in the upper Sacramento River, we can indirectly test the hypothesized tendency of naturally-produced fall chinook salmon from the upper Sacramento River to be lured, or "decoyed" into Battle Creek.

We theorized that tagged groups of delta-strays returning to the upper Sacramento River would distribute themselves according to non-homing cues, or attractants, such as flow, temperature, preferred habitat type, or, if the decoying theory is correct, large congregations of spawning adults. Support for this theory is offered by Hasler and Scholz (1983) who report that "[s]almon stop reacting to their imprinting odor at about the time of spawning and begin responding strongly to the odor of other salmon." The authors considered conspecific odors (e.g. sex hormones) especially attractive to straying adults (e.g. delta-strays). Hasler and Scholz (1983) view this as adaptive behavior to insure spawning in the event a salmon did not home correctly, whereby a straying salmon, misguided by a disrupted home-recognition system, could be attracted into a "proven" spawning area where other salmon are present. Following this reasoning, we theorized that if substantial decoying into Battle Creek is a real phenomenon, then we would expect that, during1995 through 2000, delta-strays would be strongly attracted to Battle Creek and comparatively fewer would stray to Clear Creek, another tributary to the upper Sacramento River where fall chinook salmon spawn. However, if Battle Creek is not more attractive to delta-strays than Clear Creek, then we would expect that both creeks present similar levels of attraction to true-homing, naturally produced fall chinook salmon from the upper Sacramento River. These assumptions are based on the following observations:

- The abundance of naturally-spawning fall chinook salmon in lower Battle Creek from 1995 through 2000 (60,003 six-year average) was substantially larger than the abundance in Clear Creek (7,123 six-year average).
- Both Battle and Clear creeks provide suitable flows, water temperatures, and both tributaries to the upper Sacramento River are used as spawning habitat for fall chinook salmon.

Methods:

Coded-wire tags were recovered from marked fish during fall chinook salmon escapement surveys at Battle and Clear creeks from 1995 through 2000. The California Department of Fish and Game (CDFG) calculates annual estimates of fall chinook salmon spawner abundance in both Clear and Battle Creeks using mark-and-recovery surveys of chinook salmon carcasses. While performing surveys, field crews also collect heads from fresh (clear-eyed) and marked salmon for subsequent CWT recovery and decoding. Heads are not generally recovered from non-fresh salmon because mark-status can not be readily and accurately determined from badly deteriorated fish (Colleen Harvey-Arrison, CDFG, Red Bluff, CA, personal communication).

Coded-wire tags recovered from each collection location (Clear Creek, Battle Creek, and Coleman NFH) were decoded to determine the origin of tagged fish. For CWT's recovered during the Clear Creek and Battle Creek escapement surveys, processing and decoding were accomplished primarily by CDFG personnel. For CWT's recovered at Coleman NFH, processing and decoding were accomplished by Service personnel. Marked recoveries from each collection location were enumerated and grouped, as follows, according to their location of origin and release-strategy:

1) Coleman NFH fall chinook salmon / on-site release;
2) Coleman NFH fall chinook salmon / off-site release;
3) Coleman NFH late-fall chinook salmon;
4) Feather River Hatchery spring chinook / released into Clear Creek;
5) Feather River Hatchery / delta-release;
6) Merced River Fish Facility / delta-release;
7) Mokelumne River Fish Installation / delta-release; or,
8) Unrecovered, lost, or unreadable CWT.

Specific groupings presented above were then further classified as either "non- delta-stray" (groups 1-4) or "delta-stray" (groups 5-7). Unrecovered, lost, or unreadable CWT's (group 8) collected from adipose fin-clipped salmon were allocated throughout the tagged groups proportionately throughout the various collection locations and years.

Recovery of CWT's from the Clear Creek escapement surveys is believed provide a fairly complete and representative sample of tagged salmon spawning in that tributary. In comparison, recovery of coded-wire tags from the Battle Creek survey is believed to be considerably less-complete, with only a small fraction of tags from marked salmon being recovered. The tag recovery rate in Battle Creek is low relative to Clear Creek for two primary reasons:

1) the large number of Coleman NFH salmon encountered on escapement surveys causes physical (too many heads to carry) and logistical (time) constraints which preclude the collection of heads from all marked salmon in Battle Creek; and,

2); because of the large number of fish in Battle Creek, considerably more time is required to sample that tributary as compared to Clear Creek. As a result, fewer survey trips are generally conducted at Battle Creek over the course of a season. Because field surveys are less frequent, carcasses encountered during any given survey are more likely to be found in an advanced state of deterioration. Since badly deteriorated carcasses are not examined for mark status, relatively fewer tags are recovered from Battle Creek as compared to Clear Creek.

The numbers of delta-strays recovered at Clear Creek were then expanded by the inverse of the sampled fraction to account for variability in sampling efforts in that tributary. Coded-wire tag recoveries at Coleman NFH were not expanded because heads are collected from all marked chinook salmon entering the hatchery. Because CWT recovery data in Battle Creek is relatively less-complete as compared to Clear Creek, raw tag recovery data from Battle Creek was expanded to account for sampling effort using two different methodologies:

1) *Expansion Method 1*- similar to Clear Creek, tag recovery data from carcass surveys in lower Battle Creek were expanded by the inverse of the sampled portion to account for the

expected number of tags in unsampled fish; and,

2) *Expansion Method 2* - tag recovery data from Coleman NFH (complete census) was expanded by the fraction of fish spawning naturally below the Coleman barrier weir (ie., number spawning below weir / number spawning above weir).

The largest of the expanded estimates of delta-strays in lower Battle Creek used for the statistical analysis. Although this expansion methodology is somewhat biased in favor of showing that a higher number of delta-strays returned to battle Creek, we wanted to provide a "worse-case" portrayal of evidence to suggest decoying into Battle Creek.

After expanding recoveries to reflect sampling effort, the estimated number of delta-strays in lower Battle Creek was added to the number of delta-strays actually recovered from Coleman NFH to reflect total returns of delta-strays to Battle Creek. The estimate of total return to Battle Creek was then compared to the estimated total return to Clear Creek using a one-sided Wilcoxan matched-pairs signed-ranks test (Daniel 1990). Differences between returns of delta-strays to Battle and Clear creeks were compared to test whether the median population difference ($M_D = DS_{Clear} - DS_{Battle}$) was less than zero. The specific null and alternative hypotheses tested were:

H_0: $M_D \geq 0$
H_A: $M_D < 0$.

Results:

Clear Creek

Fall chinook salmon escapement surveys conducted at Clear Creek from 1995-2000 examined between 31 and 49% of the estimated spawning populations in that tributary for mark status (n=1,644 to 3,837). The numbers of heads collected from marked fish during these survey efforts were generally low, ranging from a low of one in 1997 to a high of 62 during the 1995 survey (Table 2A), indicating generally low numbers of marked fish. Ten delta strays were recovered in 1995, two in 1996, one each in 1997 and 1998, six 1999, and three in 2000. Because relatively few salmon are encountered during the course of the four to eight week Clear Creek escapement survey (as compared to Battle Creek), examination of fish for mark-status and collection of heads from marked fish is believed to be generally complete.

Battle Creek

For fall chinook salmon escapement surveys conducted at Battle Creek from 1995-2000, between 28 and 45% of the total number of adults estimated to return to that tributary were counted and examined for mark status (n= 14,441 to 25,700). Heads were recovered from a portion of the marked fish encountered during Battle Creek survey efforts. Five-hundred fifty-seven heads were collected during 1995, 56 in 1996, 20 in 1997, 148 in 1998, 142 in 1999, and 428 in 2000. The number of delta strays recovered was five in 1995, one in 1996, none from 1997 to 1999, and one in 2000. Based on *Expansion Method 1* (above), expanded numbers of delta-strays in lower Battle Creek ranged from none (1997-1999) to 20 (1995). Based on *Expansion Method 2*,

Table 2A. Number of delta-strays recovered at Clear Creek, Battle Creek, and Coleman NFH, and expanded return estimates to each sampling location from 1995 through 2000. Total return of delta-strays to Battle Creek is equal to the sum of expanded recoveries for lower Battle Creek and Coleman NFH.

Sample Location	Return Year	Total Number Examined	Total Population Estimate	Marked Carcasses Recovered	Delta-strays	
					Sampled	Expanded
Clear Creek	1995	3,837	9,298	62	10	34
	1996	2,836	5,922	12	2	13
	1997	2,619	8,569	1	1	3
	1998	1,644	4,258	6	1	4
	1999	2,355	8,003	10	6	29
	2000	3,263	6,687	13	3	10
Coleman NFH	1995	26,677	26,677	1,068	3	4
	1996	21,178	21,178	433	7	8
	1997	50,670	50,670	1,266	5	7
	1998	44,350	44,350	2,166	1	1
	1999	26,968	26,968	1,621	2	2
	2000	21,659	21,659	902	11	13
Lower Battle Creek						
Based on Expansion of Escapement Survey Data						
	1995	25,700	56,515	557	5	20
	1996	18,809	52,404	56	1	4
	1997	14,441	50,743	20	0	0
	1998	18,695	53,957	148	0	0
	1999	22,063	92,949	142	0	0
	2000	22,532	53,447	428	1	5

Based on Expansion of Delta-strays Collected at Coleman

Return Year	Delta-strays sampled at Coleman NFH	Total Return		Expanded Delta-strays
		Coleman NFH	Lower Battle Creek	
1995	3	26,677	56,515	7
1996	8	21,178	52,404	20
1997	6	50,670	50,743	6
1998	1	44,350	53,957	1
1999	2	26,968	92,949	8
2000	13	21,659	53,447	32

the estimated total number of delta strays in lower Battle Creek ranged from one (1998) to thirty-two (2000; Table 2A). For five of the six years analyzed, *Expansion Method 2* produced the larger estimate of total delta-strays in lower Battle Creek (Table 2A).

Coleman National Fish Hatchery
All chinook salmon collected at Coleman NFH during the fall chinook spawning seasons 1995-2000 were examined for mark status, and heads were collected from all marked individuals. Numbers of marked adults collected at Coleman NFH over those years ranged from 433 (1996)to 2,166 (1998). Recovery of delta-strays at Coleman NFH totaled three in 1995, seven in 1996, five in 1997, one in 1998, two in 1999, and eleven in 2000. Expanded recovery of delta-strays ranged from one (1998) to 13 (2000).

Total Battle Creek:
Total combined estimates of delta-strays in Battle Creek (lower Battle Creek plus Coleman NFH) were 11 for 1995, 28 for 1996, 13 for 1997, 2 for 1998, 10 for 1999, and forty-five for 2000.

In comparing the numbers delta-strays for Clear Creek to total expanded recoveries for Battle Creek (lower Battle Creek and Coleman NFH), expanded recoveries of delta-strays in Clear Creek were greater than Battle Creek for three of six years analyzed. With a sample size of n = 6 (years of comparison) and a test statistic $T_+ = 9$, we could not reject the null hypothesis that the median of population differences (Clear Creek minus Battle Creek) is less than or equal to zero (P = 0.42). Available evidence suggests that from 1995 through 2000 Battle Creek *did not* attract significantly more delta- strays as compared to Clear Creek. Therefore, we conclude that available evidence do not support the theory that natural-origin fish are decoyed into Battle Creek by large congregations of spawning adults.

Discussion:

Data analyzed are not indicative of significant decoying into Battle Creek by delta-released salmon reared at hatchery facilities of the lower Sacramento or San Joaquin river systems, and do not support the hypothesis of decoying into Battle Creek. Although the available data (n = 6 years of paired data) are not sufficient to provide a statistically powerful analysis (Power = 0.35 at $\propto = 0.90$), compelling evidence were generated through this examination to characterize the likelihood of existence and the magnitude of the hypothesized "decoying problem" in Battle Creek. Data analyzed, whether through cursory examination or through a statistical test of significance, do not support the theory that large numbers of natural-origin adults from the Sacramento River are lured into Battle Creek by congregations of hatchery-origin fish.

In the present analysis, the power of the Wilcoxan paired-sample test is low (power = 0.35 at $\propto = 0.90$). Statistical power of this test is low for three primary reasons: 1) sample size is low (n = 6 years); 2) the difference between population measurements (i.e., Clear Creek minus Battle Creek) is highly variable between years ($\bar{x}_d$=4.8, s_d=12.12); and, 3) the median population difference is not large. In regard to these three primary factors that influence the power of this analysis: 1) statistical power will likely be substantially increased with increased sample size (i.e., continued years of study); 2) inter-annual variability ($\sigma^{2)}$ is estimated by s^2, and s^2 will also improve when it is estimated from a larger sample size (i.e., increased years of study); and, 3) the difference between the measured difference and the expected mean difference (Clear Creek minus Battle Creek) under the null hypothesis (H_0: $M_D \leq 0$) is small. The farther a population characteristic (in this study: the difference between the number of delta-strays returning to Clear and Battle Creek) is from that stated in the null hypothesis (in this study the null hypothesis was no difference between numbers of delta-strays returning to Clear and Battle Creeks), the greater will be the power to reject the null hypothesis. In the present investigation, the number of delta-strays returning to Clear and Battle Creeks was not substantively different. The estimated number of delta-strays returning to Clear Creek was an average approximately 5 more than the total number returning to Battle Creek and Coleman NFH. For 3 of the 6 years of investigation, the number of delta-strays returning to Clear Creek was greater than the total number returning to Battle Creek and Coleman NFH. As a result, the statistical power of the analysis (the ability of the test to show that natural-origin fish were decoyed into Battle Creek) was, as anticipated, low. Future analyses of decoying in Battle Creek will be improved by increased replication (more years of data), increased effort at collecting heads during escapement surveys, and improved escapement estimates in Clear and Battle Creeks.

An alternative manner of examining the statistical power of the specific hypothesis being tested would be to examine the difference between the observed values and the values expected under the null hypothesis should the decoying theory actually hold true. For example, over the years of investigation (1995 - 2000) the estimated spawning populations in Battle Creek (Coleman NFH plus lower Battle Creek) were an average of 13.75 times larger (s=4.97, range 9-23) than returns to Clear Creek. If the level of false attraction (decoying) into each tributary was similar to the size of the spawning populations in each tributary, we would expect a similar ratio (approx. 13.75:1) of decoyed delta-strays between Battle and Clear Creeks. Under this situation, a Wilcoxan paired-sample test would have provided a power of 0.85 (α=0.90). In other words, 85% of studies conducted under these circumstances would be expected to show a significant effect - leading to rejection of the null hypothesis that the population difference is zero. However, the test of significance in this investigation was not significant (P=0.42).

Although available data do not facilitate a powerful statistical analysis, we consider the decoy analysis sufficiently robust to show large differences in numbers of delta-strays (as surrogates for naturally-produced fall chinook salmon) returning to Clear and Battle creeks. The following aspects of the study design were used to create a very robust analysis of the decoying theory:

- We believe that, if the decoying effect were in fact real, delta-strays would be decoyed into Battle Creek at a higher rate than naturally-produced, true-homing salmon that were born and reared in the upper Sacramento River. Hasler and Scholz (1983) report that conspecific odors (e.g., sex hormones) produced by spawning adults likely "...do not provide specific homing cues but instead may act as generalized attractants providing fish *which have failed to home correctly* with a mechanism for attracting them to sites with other spawning adults, thereby allowing for completion of their life cycles" (emphasis added). Therefore, following this reasoning and considering the results of our analysis, we conclude that true-homing salmon produced in the upper Sacramento River are not decoyed in substantial numbers into Battle Creek, despite large congregations of hatchery-origin adults.

- If large numbers of fall chinook salmon were indeed being lured from the upper Sacramento River into Battle Creek, delta-strays should be biased favorably towards returning to Battle Creek because of the relative locations of Battle Creek and Clear Creek to the Sacramento River migration corridor. During their migration up the Sacramento River, adult fall chinook salmon encounter the confluence of Battle Creek prior to Clear Creek. Therefore, if large congregations of spawning adults in lower Battle Creek provide a strong attractant to migrating salmon, then decoyed fish would likely remain in the vicinity of Battle Creek at river mile (RM) 271.5 and not travel upstream another approximately 18 miles to the Clear Creek confluence at RM 289.4. However, our analysis did not show increased attraction of fall chinook salmon into Battle Creek greater than the level of attraction into Clear Creek.

We suggest that most fall chinook salmon returning to Coleman NFH and Battle Creek originated naturally in that tributary or through artificial production at the hatchery. Juvenile monitoring data collected from Battle Creek corroborate the results of this investigation suggesting that natural production in Battle Creek is sufficient to produce substantial contribution to that tributary's spawning populations. Natural production of fall chinook salmon in Battle Creek for BY's 1998 and 1999 are 14.2 million and 26.5 million, respectively (preliminary unpublished data, USFWS, RBFWO, Red Bluff, CA). During those years, natural production in the three miles immediately below the Coleman barrier weir amounted to 99% and 89% of total fall chinook production in the tributary. These data indicate successful spawning and substantial numbers of fall chinook juveniles surviving to emigrate from Battle Creek, and suggest the potential for substantial contribution to adult returns, even during years of dramatic over-escapement into that tributary.

Literature Cited

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Appendix 3A. Chinook salmon recoveries of coded-wire tagged groups from Coleman and Livingston Stone National Fish Hatcheries and the Tehama-Colusa Fish Facility. Ocean catch values are expanded from the number of tagged fish sampled to estimate the total number of tagged fish harvested for each age class. Total home values are actual counts of tagged fish returning to the hatchery for each age class. All data were obtained from the Regional Mark Information System (RMIS) of the Pacific States Marine Fisheries Comission, except for late fall hatchery returns which come from the U.S. Fish and Wildlife Service, unpublished data.

				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1973	Fall	050110	0	0	45	33	0	0	78	0	9	7	6	0	22	0	0	0	0	TCFF
1974	Fall	050710	0	0	168	179	6	0	353	0	6	18	18	0	42	0	0	0	0	TCFF
1975	Late-fall	060301	0	32	100	4	0	0	136	0	0	0	0	0	0	0	0	0	0	
1975	Fall	060303	0	0	89	9	0	0	98	0	0	0	0	0	0	0	3	0	3	
1975	Fall	060304	0	11	192	0	0	0	203	0	0	0	0	0	0	0	0	0	0	
1975	Fall	060305	0	0	115	23	0	0	138	0	0	0	0	0	0	0	0	3	3	
1975	Fall	141310	0	7	1076	99	3	0	1185	0	0	69	36	0	105	0	0	3	3	TCFF
1975	Fall	141410	0	0	206	15	0	0	221	0	0	6	2	0	8	0	0	0	0	TCFF
1976	Fall	054801	0	39	299	11	0	0	349	0	11	38	1	0	50	0	0	0	0	TCFF
1976	Late-fall	060307	0	18	27	0	0	0	45	0	0	0	0	0	0	0	0	0	0	
1976	Fall	066008	0	0	21	0	0	0	21	0	0	0	0	0	0	0	0	0	0	
1976	Fall	066009	0	27	165	11	0	0	203	0	0	0	0	0	0	0	0	0	0	
1976	Fall	066010	0	18	127	0	0	0	145	0	0	0	0	0	0	0	0	0	0	
1976	Fall	066011	0	11	39	0	0	0	50	0	0	0	1	0	1	0	0	0	0	
1977	Fall	050320	0	117	1139	49	0	0	1305	0	24	34	9	0	67	0	0	0	0	TCFF
1977	Late-fall	066012	19	1549	524	14	0	0	2106	0	0	0	28	3	31	0	3	0	3	1 six yr. Old return to TCFF
1978	Fall	050430	0	0	12	2	0	0	14	0	0	0	0	0	0	0	0	0	0	TCFF
1978	Fall	050452	0	19	217	13	0	0	249	0	5	6	3	0	14	0	0	0	0	TCFF
1978	Winter	050453	0	37	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	
1978	Late-fall	066013	0	91	27	0	0	0	118	0	0	17	6	0	23	0	0	0	0	
1978	Late-fall	066014	0	230	73	3	0	0	306	0	0	9	6	0	15	0	0	0	0	1 three & 2 four yr. Old to TCFF
1978	Late-fall	066015	0	176	33	0	0	0	209	0	0	10	7	0	17	0	0	0	0	1 three yr. Old to TCFF
1978	Fall	H50103	0	26	291	11	0	0	328	0	1	0	6	0	7	7	0	0	7	TCFF
1979	Fall	050617	0	0	49	5	0	0	54	0	0	3	0	0	3	0	0	0	0	TCFF
1979	Fall	050618	0	46	371	19	0	0	436	0	5	12	1	0	18	0	0	0	0	TCFF
1979	Fall	050619	0	23	268	18	0	0	309	0	6	4	1	0	11	0	0	0	0	TCFF
1979	Fall	050620	0	0	29	0	0	0	29	0	1	0	0	0	1	0	0	0	0	TCFF
1979	Late-fall	066022	0	412	474	3	0	0	889	0	4	56	22	1	83	0	7	0	7	
1979	Late-fall	066023	0	294	308	9	0	0	611	0	4	67	30	0	101	0	0	0	0	
1979	Fall	H50204	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
1979	Fall	H50205	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	
1979	Fall	H50206	0	5	24	0	0	0	29	0	1	3	0	0	4	0	0	0	0	
1979	Fall	H50207	0	4	55	0	0	0	59	0	2	1	0	0	3	0	0	0	0	
1979	Fall	H50301	0	23	92	19	0	0	134	0	8	20	4	0	32	0	3	0	3	
1979	Fall	H50302	0	3	115	4	0	0	122	0	6	13	1	0	20	13	15	0	28	
1979	Fall	H50303	0	2	24	2	0	0	28	0	0	4	0	0	4	0	0	0	0	
1979	Fall	H50304	0	7	33	1	0	0	41	0	1	1	0	0	2	0	0	0	0	
1979	Fall	H50305	0	20	46	22	0	0	88	0	8	15	2	0	25	0	8	0	8	
1979	Fall	H50306	0	3	121	6	0	0	130	0	3	8	2	0	13	0	3	0	3	
1980	Fall	050557	0	37	132	8	0	0	177	0	9	6	0	0	15	0	0	0	0	TCFF
1980	Fall	050558	0	21	134	0	0	0	155	0	10	8	0	0	18	0	0	0	0	TCFF
1980	Fall	050559	0	28	162	2	0	0	192	0	10	4	2	0	16	0	0	0	0	TCFF

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				Ocean Catch						Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1980	Fall	050560	0	51	177	0	0	0	228	0	9	10	1	0	20	0	0	0	0	TCFF
1980	Fall	050561	0	22	125	0	0	0	147	0	4	10	1	0	15	0	0	0	0	TCFF
1980	Fall	050562	0	13	43	0	0	0	56	0	4	0	1	0	5	0	0	0	0	TCFF
1980	Fall	066016	0	59	218	4	0	0	281	0	47	51	7	0	105	5	0	0	5	
1980	Fall	066017	0	81	298	14	0	0	393	0	42	41	3	0	86	0	0	0	0	1 one yr. Old river catch
1980	Fall	066018	0	170	129	0	0	0	299	0	5	13	3	0	21	0	0	0	0	
1980	Late-fall	066019	0	287	182	8	10	0	487	0	0	11	1	0	12	0	0	0	0	3 seven yr. Old ocean troll
1980	Fall	066020	0	36	127	11	0	0	174	0	8	6	1	0	15	0	0	0	0	estimated (1 actual)
1980	Fall	066021	0	31	210	5	0	0	246	0	6	7	1	0	14	0	0	0	0	
1980	Fall	H50202	0	34	132	5	0	0	171	0	11	5	0	0	16	0	0	0	0	TCFF
1980	Fall	H50203	0	25	263	12	0	0	300	0	6	1	0	1	8	0	0	0	0	TCFF
1980	Fall	H60101	0	9	28	0	0	5	42	0	8	10	0	0	18	0	0	0	0	
1980	Fall	H60102	0	0	16	0	0	0	16	0	1	3	0	0	4	0	0	0	0	
1980	Fall	H60103	0	0	10	0	0	0	10	0	2	1	0	0	3	0	0	0	0	
1980	Fall	H60104	0	0	6	0	0	0	6	0	0	0	0	0	0	0	0	0	0	
1980	Fall	H60105	0	17	46	1	0	0	64	0	6	8	2	0	16	0	0	0	0	
1980	Fall	H60106	0	10	58	4	0	0	72	0	0	0	0	0	0	0	0	0	0	
1980	Fall	H60107	0	10	26	0	0	0	36	0	0	0	0	0	0	0	0	0	0	
1980	Fall	H60201	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	
1981	Fall	066024	0	49	60	4	0	0	113	1	27	21	3	0	52	0	0	0	0	
1981	Fall	066025	0	44	54	11	0	0	109	1	20	29	2	0	52	0	0	0	0	
1981	Fall	066026	0	12	220	50	4	0	286	0	10	117	41	1	169	0	14	4	18	
1981	Fall	066027	0	16	357	86	7	0	466	0	8	76	61	0	145	0	11	7	18	
1981	Fall	066028	0	18	236	78	6	0	338	0	11	118	46	1	176	0	18	7	25	
1981	Fall	066029	0	11	290	76	14	0	391	0	7	89	52	0	148	0	21	4	25	
1981	Fall	066030	0	9	319	69	0	0	397	0	9	69	42	1	121	0	7	2	9	
1981	Fall	066031	0	11	225	68	0	0	304	0	11	77	36	0	124	0	4	2	6	
1981	Fall	066218	0	23	738	318	8	0	1087	0	0	22	29	0	51	0	0	0	0	
1981	Fall	066219	0	20	457	301	4	0	782	0	0	14	16	0	30	0	0	0	0	
1981	Fall	H60202	0	8	100	7	0	0	115	0	1	49	16	0	66	0	7	2	9	
1981	Fall	H60203	0	12	17	0	2	0	31	0	0	3	1	0	4	0	4	0	4	
1981	Fall	H60204	0	0	7	9	0	0	16	0	0	1	0	0	1	0	0	0	0	8 eight yr. Old estimated ocean
1981	Fall	H60205	0	0	0	5	0	0	5	0	0	1	0	0	1	0	0	0	0	troll catches (1 actual catch by
1981	Fall	H60206	0	9	85	24	0	0	118	0	1	28	18	0	47	0	4	2	6	ODFW in 1989, fl 763 mm)?
1981	Fall	H60207	0	3	5	4	0	0	12	0	0	0	0	0	0	0	0	0	0	
1981	Fall	H60301	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	
1981	Fall	H60302	0	3	14	5	0	0	22	0	0	0	1	0	1	0	0	0	0	
1982	Winter	050429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1982	Fall	066032	0	3	60	9	0	0	72	0	0	1	3	0	4	0	0	0	0	
1982	Fall	066033	0	0	46	9	0	0	55	0	0	8	4	0	12	0	0	0	0	
1982	Fall	066034	0	0	22	0	0	0	22	0	1	4	3	0	8	0	0	0	0	
1982	Fall	066035	0	0	36	36	0	0	72	0	1	3	4	0	8	0	0	0	0	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1982	Fall	066036	0	0	67	29	0	0	96	0	0	15	7	0	22	0	2	0	2	
1982	Fall	066037	0	0	79	18	0	0	97	0	1	6	5	0	12	0	2	0	2	
1983	Fall	066038	0	125	765	63	0	0	953	0	19	20	6	0	45	0	3	0	3	
1983	Fall	066039	0	133	849	20	0	0	1002	0	24	30	3	0	57	2	5	2	9	
1983	Fall	066040	0	129	882	42	3	0	1056	0	64	107	17	0	188	2	16	7	25	
1983	Fall	066041	0	172	907	72	0	0	1151	0	73	124	15	1	213	0	11	2	13	
1983	Fall	066042	0	144	714	41	21	0	920	0	108	159	24	1	292	4	19	0	23	
1983	Fall	066043	0	104	724	23	0	0	851	0	81	193	24	0	298	7	16	0	23	
1983	Fall	H60404	0	27	88	3	6	0	124	0	2	14	2	0	18	0	3	0	3	
1983	Fall	H60405	0	11	44	6	0	0	61	0	2	5	0	0	7	0	0	0	0	
1983	Fall	H60406	0	2	76	4	0	0	82	0	3	7	2	0	12	0	0	0	0	
1983	Fall	H60407	0	0	54	7	0	0	61	0	0	1	0	0	1	0	0	0	0	
1983	Fall	H60501	0	0	33	6	0	0	39	0	0	0	0	0	0	0	0	0	0	
1983	Fall	H60502	0	6	136	0	0	0	142	0	1	4	3	0	8	0	0	0	0	
1983	Fall	H60503	0	25	132	21	0	0	178	0	2	15	3	0	20	0	0	0	0	
1983	Fall	H60504	0	9	217	8	0	0	234	0	8	41	10	0	59	0	5	7	12	
1984	Fall	050563	0	3	29	0	0	0	32	0	0	0	0	0	0	0	0	0	0	TCFF
1984	Fall	050616	0	0	0	0	0	0	0	0	3	1	0	0	4	0	0	0	0	
1984	Fall	050735	0	20	55	6	0	0	81	0	0	0	0	0	0	0	0	0	0	TCFF
1984	Fall	050736	0	4	55	4	0	0	63	0	0	0	0	0	0	0	0	0	0	TCFF
1984	Fall	050947	0	2	25	0	0	0	27	0	3	2	0	0	5	0	0	0	0	
1984	Fall	050948	0	6	53	11	0	0	70	0	0	7	0	0	7	0	0	0	0	
1984	Fall	050949	0	7	49	12	0	0	68	0	0	1	0	0	1	0	0	0	0	
1984	Fall	050950	0	4	217	71	0	0	292	0	5	23	5	0	33	0	0	3	3	TCFF
1984	Fall	050951	0	0	204	63	7	0	274	0	8	16	3	0	27	0	0	3	3	TCFF
1984	Fall	053904	0	0	0	0	0	0	0	0	1	3	0	0	4	0	2	0	2	
1984	Fall	054004	0	0	21	0	0	0	21	0	0	1	0	0	1	0	0	0	0	
1984	Fall	054104	0	0	8	0	0	0	8	0	1	2	0	0	3	0	0	0	0	
1984	Fall	054204	0	0	47	0	0	0	47	0	1	3	0	0	4	0	0	0	0	
1984	Fall	054304	0	0	27	0	0	0	27	0	1	4	0	0	5	0	0	0	0	
1984	Fall	H50105	0	0	32	0	0	0	32	0	0	5	0	0	5	0	0	3	3	
1984	Fall	H50106	0	0	21	5	0	0	26	0	1	2	0	0	3	0	0	0	0	
1984	Fall	H50107	0	0	34	0	0	0	34	0	0	5	0	0	5	0	2	0	2	4 three yr. Olds in Columbia R. gillnet
1984	Fall	H50201	0	3	147	74	0	0	224	0	7	24	2	0	33	0	0	3	3	TCFF
1984	Fall	H50307	0	3	9	0	0	0	12	0	0	1	4	0	5	0	2	0	2	
1984	Fall	H50401	0	0	0	11	0	0	11	0	0	3	3	0	6	0	2	3	7	
1984	Fall	H60501	0	0	35	3	0	0	38	0	0	0	0	0	0	0	0	0	0	TCFF
1984	Fall	H60505	0	14	60	0	0	0	74	0	0	15	0	0	15	0	2	3	5	
1984	Fall	H60506	0	12	84	6	0	0	102	0	1	5	0	0	6	0	2	0	2	
1984	Fall	H60507	0	7	74	2	0	0	83	0	0	3	0	0	3	0	2	0	2	
1984	Fall	H60601	0	6	44	19	0	0	69	0	0	4	1	0	5	0	0	3	3	
1984	Fall	H60602	0	6	63	8	0	0	77	0	1	6	0	0	7	0	0	0	0	

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			Ocean Catch							Hatchery Returns						Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1984	Fall	H60603	0	6	77	15	0	0	98	0	0	7	0	0	7	0	0	6	6	
1984	Fall	H60604	0	8	81	0	0	0	89	0	0	4	2	0	6	0	4	3	7	
1984	Fall	H60605	0	13	126	59	0	0	198	0	0	12	0	0	12	0	4	0	4	
1985	Fall	051843	0	7	474	148	0	0	629	0	0	2	1	0	3	0	0	4	4	TCFF
1985	Fall	051844	0	26	292	75	0	0	393	0	0	1	1	2	4	0	0	2	2	TCFF
1985	Fall	H50402	0	11	302	21	0	0	334	0	20	31	5	1	57	0	3	2	5	
1985	Fall	H50403	0	10	271	33	0	0	314	0	22	37	6	0	65	0	28	2	30	
1985	Fall	H50404	0	41	296	28	0	0	365	0	14	26	7	0	47	0	25	0	25	
1985	Fall	H50405	0	41	348	53	0	0	442	0	23	36	6	0	65	0	34	4	38	
1985	Fall	H50406	0	75	497	23	0	0	595	0	30	33	2	0	65	0	22	2	24	
1985	Fall	H50407	0	37	357	27	0	0	421	0	24	18	7	0	49	0	22	0	22	
1985	Fall	H50707	0	33	170	17	0	0	220	0	10	32	13	0	55	0	19	11	2	6 in Columbia R gillnet
1985	Fall	H60607	0	2	18	0	2	0	22	0	1	1	0	0	2	0	0	0	0	
1985	Fall	H60702	0	1	65	17	0	0	83	0	1	5	0	0	6	0	0	0	0	
1985	Fall	H60703	0	10	59	17	0	0	86	0	1	2	0	0	3	0	0	0	0	
1985	Fall	H60704	0	3	124	0	0	0	127	0	0	6	1	0	7	0	9	0	9	
1985	Fall	H60705	0	23	353	43	0	0	419	0	9	30	3	0	42	0	56	6	62	
1986	Fall	051839	0	12	408	37	0	0	457	0	4	25	17	0	46	3	17	3	23	
1986	Fall	051840	0	8	341	9	0	0	358	0	7	17	9	0	33	0	8	5	13	
1986	Fall	051841	0	2	154	19	0	0	175	0	4	4	3	0	11	0	2	0	2	
1986	Fall	B50205	0	19	358	54	0	0	431	0	0	1	2	0	3	0	0	0	0	TCFF
1986	Fall	B50413	0	8	67	7	0	0	82	0	0	10	9	0	19	0	11	0	11	
1986	Fall	H60706	0	0	28	0	0	0	28	0	0	1	0	0	1	0	0	0	0	
1986	Fall	H60707	0	10	103	2	0	0	115	0	3	18	4	0	25	0	2	4	6	
1987	Fall	051842	0	34	286	8	0	0	328	0	0	7	0	0	7	0	2	0	2	2 Two yr. Olds to Nimbus,
1987	Fall	051939	0	40	341	12	0	0	393	0	5	53	12	0	70	0	11	3	14	
1987	Fall	051940	0	40	425	4	0	0	469	0	5	54	15	0	74	0	8	5	13	
1987	Fall	051941	0	59	349	5	0	0	413	0	0	31	9	0	40	0	8	3	11	
1987	Fall	B50206	0	0	19	0	0	0	19	0	1	6	2	0	9	0	0	0	0	
1987	Fall	B61401	0	2	108	10	0	0	120	0	2	18	6	0	26	0	5	3	8	
1988	Fall	052037	0	34	41	8	0	0	83	0	1	20	10	0	31	0	6	2	8	
1988	Fall	052038	0	25	63	4	0	0	92	0	2	14	7	0	23	0	2	7	9	
1988	Fall	052039	0	11	74	5	0	0	90	0	2	16	4	0	22	0	2	1	3	
1988	Fall	052040	0	2	169	25	0	0	196	0	2	0	2	0	4	0	0	0	0	
1989	Late-fall	052053	0	6	8	0	0	0	14	0	0	0	1	0	1	0	0	0	0	
1989	Late-fall	052054	0	0	26	0	0	0	26	0	0	1	6	1	8	0	0	0	0	
1989	Fall	052055	0	0	26	13	0	0	39	0	0	3	4	0	7	2	4	0	6	
1989	Fall	052056	0	0	24	9	0	0	33	0	0	6	2	0	8	0	2	0	2	
1989	Fall	052057	0	0	12	0	0	0	12	0	0	2	1	0	3	0	0	0	0	
1989	Fall	052058	0	5	200	39	0	0	244	0	0	10	1	0	11	0	4	2	6	
1990	Fall	0501010104	0	40	621	79	0	0	740	0	15	28	14	0	57	0	6	19	25	
1990	Fall	0501010110	0	3	30	9	0	0	42	0	0	8	2	0	10	0	2	5	7	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1990	Fall	0501010111	0	0	13	9	0	0	22	0	1	6	0	0	7	0	0	5	5	
1990	Fall	0501010112	0	31	288	56	0	0	375	0	8	60	27	0	95	2	29	39	70	
1990	Fall	0501010113	0	14	226	34	0	0	274	0	6	53	18	0	77	0	10	17	27	
1990	Fall	051845	0	5	23	0	0	0	28	0	2	5	1	0	8	0	0	3	3	
1990	Fall	051847	0	5	52	14	0	0	71	0	2	10	6	0	18	1	0	5	6	
1990	Fall	051848	0	5	54	16	0	0	75	0	2	14	1	0	17	0	6	3	9	
1991	Late-fall	0501010308	0	122	95	2	3	0	222	0	27	96	13	2	138	0	0	0	0	
1991	Late-fall	0501010309	0	238	155	0	0	0	393	0	25	78	22	2	127	1	0	0	1	
1991	Fall	0501010310	0	0	8	6	0	0	14	0	0	3	0	0	3	0	0	0	0	
1991	Winter	0501010403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1991	Winter	0501010404	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1991	Winter	0501010405	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	
1991	Winter	0501010406	0	7	3	0	0	0	10	0	0	0	0	0	0	0	0	0	0	
1991	Fall	052812	0	16	27	8	0	0	51	0	1	3	0	0	4	0	10	0	10	
1991	Fall	052813	0	5	31	4	0	0	40	0	8	5	1	0	14	0	9	0	9	
1991	Fall	052814	0	0	7	0	0	0	7	0	1	3	0	0	4	0	2	0	2	
1991	Fall	052818	0	0	34	2	0	0	36	0	2	13	2	0	17	0	9	0	9	
1991	Fall	052819	0	24	117	14	0	0	155	0	2	18	2	0	22	0	10	0	10	
1991	Fall	052830	0	33	711	115	0	0	859	0	9	32	5	0	46	2	43	0	45	
1991	Fall	0601110206	0	6	5	0	0	0	11	0	0	1	0	0	1	0	2	0	2	
1991	Fall	0601110207	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
1991	Fall	0601110208	0	0	8	0	3	0	11	0	0	0	0	0	0	0	2	0	2	
1991	Fall	0601110209	0	0	0	0	3	0	3	0	0	0	1	0	1	0	0	0	0	
1991	Fall	B50203	0	0	19	2	0	0	21	0	0	5	1	0	6	0	0	0	0	
1992	Winter	0501010607	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010608	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010609	0	24	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010610	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010611	0	15	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010612	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	
1992	Winter	0501010613	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010614	0	22	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010615	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010702	0	7	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010703	0	6	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010704	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010705	0	10	0	0	0	0	10	0	0	1	0	0	1	0	0	0	0	
1992	Winter	0501010706	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010707	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010708	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010709	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1992	Winter	0501010710	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
1992	Winter	0501010711	0	10	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	Tehama-Colusa FF; Temp. tolerance ex
1992	Winter	0501010712	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	
1992	Winter	0501010713	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1992	Winter	0501010714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Fall	0501010801	0	48	341	42	7	0	438	0	11	29	2	1	43	3	0	0	3	
1992	Fall	0501010802	0	59	342	33	0	0	434	0	7	30	4	0	41	2	0	0	2	
1992	Fall	0501010803	0	46	653	106	3	0	808	0	30	96	47	0	173	3	0	0	3	
1992	Fall	0501010804	0	110	1105	66	3	0	1284	0	73	148	32	0	253	3	0	0	3	
1992	Fall	0501010805	0	156	1093	110	5	0	1364	0	69	176	40	0	285	5	0	0	5	
1992	Late-fall	052859	0	245	185	6	0	0	436	0	22	58	44	1	125	0	2	0	2	
1992	Late-fall	052862	0	244	125	0	0	0	369	0	35	63	59	1	158	0	0	0	0	
1992	Late-fall	053120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1992	Late-fall	053121	3	342	250	2	2	0	599	0	25	66	80	0	171	0	2	0	2	
1992	Late-fall	053122	9	940	547	21	2	0	1519	0	68	189	175	1	433	0	3	0	3	
1992	Fall	0801141101	0	95	459	32	0	0	586	0	33	47	10	0	90	2	0	0	2	
1992	Fall	0801141102	0	35	429	44	0	0	508	0	35	47	9	0	91	2	0	0	2	
1993	Winter	0501010810	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010811	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010812	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010814	0	0	0	0	6	0	6	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010815	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010901	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010902	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010903	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010904	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010905	0	9	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010906	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1993	Winter	0501010907	0	5	5	0	0	0	10	0	0	0	1	0	1	0	0	0	0	Represents observed returns
1993	Fall	0501010908	0	0	24	3	0	0	27	0	1	5	2	0	8	0	0	0	0	
1993	Fall	0501010909	0	3	39	10	0	0	52	0	0	3	4	0	7	0	0	0	0	
1993	Late-fall	053316	0	135	138	0	0	0	273	0	3	77	70	8	158	0	0	0	0	
1993	Late-fall	053317	0	47	59	8	0	0	114	0	1	10	28	2	41	0	0	0	0	
1993	Late-fall	053408	0	124	113	0	0	0	237	0	2	61	57	2	122	0	0	0	0	
1993	Late-fall	053409	0	99	111	3	0	0	213	0	1	70	33	0	104	0	0	0	0	
1993	Late-fall	053410	0	55	89	1	0	0	145	0	0	29	26	0	55	0	0	0	0	
1993	Late-fall	053411	0	43	105	3	0	0	151	0	4	19	48	3	74	0	0	0	0	
1993	Late-fall	053412	0	60	158	0	0	0	218	0	0	29	52	2	83	0	0	0	0	
1993	Late-fall	053413	0	269	189	8	0	0	466	0	2	99	104	1	206	0	0	0	0	
1993	Late-fall	053414	0	128	93	7	0	0	228	0	4	37	32	1	74	0	0	0	0	
1993	Late-fall	053415	0	104	114	2	0	0	220	0	7	62	52	2	123	0	0	0	0	
1993	Late-fall	053417	0	0	16	0	0	0	16	0	0	1	0	0	1	0	0	0	0	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1993	Fall	053427	0	10	105	23	2	0	140	0	1	9	11	1	22	0	0	0	0	
1993	Fall	053428	0	18	195	34	4	0	251	0	9	24	28	0	61	0	0	0	0	
1993	Fall	053429	0	56	304	51	2	0	413	0	7	35	32	0	74	0	0	0	0	
1993	Late-fall	064521	0	31	48	0	0	0	79	0	1	8	2	1	12	0	0	0	0	
1993	Late-fall	064522	4	127	146	10	0	0	287	0	3	21	12	0	36	0	0	0	0	
1994	Winter	0501011002	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011009	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
1994	Winter	0501011010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011011	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011012	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	Represents observed returns
1994	Winter	0501011013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011015	0	5	0	0	0	0	5	0	0	2	0	0	2	0	0	0	0	
1994	Winter	0501011101	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	Represents observed returns
1994	Winter	0501011102	0	0	5	0	0	0	5	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011103	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
1994	Winter	0501011104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011105	0	0	4	0	0	0	4	0	0	4	0	0	4	0	0	0	0	
1994	Winter	0501011106	0	0	4	0	0	0	4	0	0	5	1	0	6	0	0	0	0	
1994	Winter	0501011107	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
1994	Winter	0501011108	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011109	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011111	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011112	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	Represents observed returns
1994	Winter	0501011113	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011114	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1994	Winter	0501011115	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	Represents observed returns
1994	Winter	0501011201	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Winter	0501011203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1994	Fall	0501011204	0	4	347	45	1	0	397	0	2	54	20	0	76	0	0	0	0	
1994	Fall	0501011205	0	0	303	25	7	0	335	0	4	48	16	0	68	0	0	0	0	
1994	Fall	0501011206	0	0	460	54	3	0	517	0	11	108	40	0	159	0	0	0	0	
1994	Fall	0501011207	0	4	423	66	0	0	493	0	11	109	28	0	148	0	0	0	0	
1994	Fall	0501011208	0	0	286	59	0	0	345	0	21	68	34	0	123	0	0	0	0	

Appendix 3A. Chinook salmon recoveries of coded-wire tagged groups from Coleman and Livingston Stone National Fish Hatcheries and the Tehama-Colusa Fish Facility. Ocean catch values are expanded from the number of tagged fish sampled to estimate the total number of tagged fish harvested for each age class. Total home values are actual counts of tagged fish returning to the hatchery for each age class. All data were obtained from the Regional Mark Information System (RMIS) of the Pacific States Marine Fisheries Comission, except for late fall hatchery returns which come from the U.S. Fish and Wildlife Service, unpublished data.

				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1994	Late-fall	053425	0	6	5	0	0	0	11	0	2	6	0	0	8	0	0	0	0	
1994	Late-fall	053426	0	15	13	0	0	0	28	0	2	11	0	0	13	0	0	0	0	
1994	Late-fall	053546	0	130	114	0	0	0	244	0	42	270	53	2	367	0	0	0	0	
1994	Late-fall	053620	13	1004	692	7	0	0	1716	0	338	1811	304	10	2463	0	0	0	0	
1994	Late-fall	053621	0	480	791	22	0	0	1293	0	144	661	167	8	980	0	0	0	0	
1994	Late-fall	053622	0	152	111	0	0	0	263	0	18	213	45	2	278	0	0	0	0	
1994	Late-fall	053742	0	170	107	0	0	0	277	0	21	223	46	1	291	0	0	0	0	
1994	Late-fall	053743	5	145	180	0	0	0	330	0	37	300	72	0	409	0	0	0	0	
1994	Late-fall	062524	0	151	106	0	0	0	257	0	7	115	16	0	138	0	0	0	0	
1994	Late-fall	062525	0	59	41	0	0	0	100	0	1	43	9	0	53	0	0	0	0	
1995	Winter	0501011301	0	7	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011305	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
1995	Winter	0501011306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011308	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	
1995	Winter	0501011309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011401	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011402	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011404	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011406	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011408	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011409	0	5	0	4	0	0	9	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011411	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011412	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011413	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011415	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011501	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011502	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Appendix 3A.

Chinook salmon recoveries of coded-wire tagged groups from Coleman and Livingston Stone National Fish Hatcheries and the Tehama-Colusa Fish Facility. Ocean catch values are expanded from the number of tagged fish sampled to estimate the total number of tagged fish harvested for each age class. Total home values are actual counts of tagged fish returning to the hatchery for each age class. All data were obtained from the Regional Mark Information System (RMIS) of the Pacific States Marine Fisheries Comission, except for late fall hatchery returns which come from the U.S. Fish and Wildlife Service, unpublished data.

BY	Run	Tag Code	Ocean Catch							Hatchery Returns						Battle Creek				Notes
			Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	
1995	Winter	0501011505	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Winter	0501011506	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1995	Fall	0501020114	0	90	571	51	0	0	712	0	43	185	0	0	228	0	0	0	0	
1995	Fall	0501020115	0	141	968	254	0	0	1363	0	96	421	0	0	517	0	0	0	0	
1995	Fall	0501020201	0	166	1467	289	0	0	1922	0	175	733	0	0	908	0	0	0	0	
1995	Late-fall	053418	3	196	46	12	0	0	257	0	4	94	62	0	160	0	0	0	0	
1995	Late-fall	053618	16	938	166	0	0	0	1120	0	37	534	160	0	731	0	0	0	0	
1995	Late-fall	053627	0	175	35	0	0	0	210	0	9	64	25	0	98	0	0	0	0	1 one yr. Old hatchery return
1995	Late-fall	053628	5	328	41	11	0	0	385	0	9	185	56	0	250	0	0	0	0	
1995	Late-fall	054107	0	328	59	6	0	0	393	0	3	118	45	0	166	0	0	0	0	
1995	Late-fall	054108	0	361	110	0	0	0	471	0	27	286	101	0	414	0	0	0	0	
1995	Late-fall	054109	0	496	62	7	0	0	565	0	13	221	71	0	305	0	0	0	0	
1995	Late-fall	054111	0	229	35	0	0	0	264	0	5	26	7	0	38	0	0	0	0	
1995	Late-fall	054112	0	196	26	6	0	0	228	0	1	18	3	0	22	0	0	0	0	
1995	Late-fall	054113	0	124	24	0	0	0	148	0	0	7	2	0	9	0	0	0	0	
1995	Late-fall	054114	0	210	24	8	0	0	242	0	1	19	3	0	23	0	0	0	0	
1995	Late-fall	054116	0	169	28	5	0	0	202	0	5	123	57	0	185	0	0	0	0	
1995	Late-fall	054117	0	548	102	15	0	0	665	0	52	341	108	0	501	0	0	0	0	
1995	Late-fall	054118	0	199	97	5	0	0	301	0	0	30	80	0	110	0	0	0	0	
1995	Late-fall	054119	0	247	67	26	0	0	340	0	0	27	57	0	84	0	0	0	0	
1996	Winter	0501020207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1996	Fall	0501020208	0	14	125	0	0	0	139	0	13	0	0	0	13	0	0	0	0	
1996	Fall	0501020209	0	0	118	0	0	0	118	0	14	0	0	0	14	0	0	0	0	
1996	Fall	0501020210	0	5	180	0	0	0	185	0	10	0	0	0	10	0	0	0	0	
1996	Fall	0501020211	0	0	133	0	0	0	133	0	3	0	0	0	3	0	0	0	0	
1996	Fall	0501020212	0	9	85	0	0	0	94	0	7	0	0	0	7	0	0	0	0	
1996	Fall	0501020213	0	5	143	0	0	0	148	0	6	0	0	0	6	0	0	0	0	
1996	Fall	0501020214	0	14	179	0	0	0	193	0	8	0	0	0	8	0	0	0	0	
1996	Fall	0501020215	0	10	153	0	0	0	163	0	6	0	0	0	6	0	0	0	0	
1996	Fall	0501020301	0	0	70	0	0	0	70	0	15	0	0	0	15	0	0	0	0	
1996	Fall	0501020302	0	3	126	0	0	0	129	0	10	0	0	0	10	0	0	0	0	
1996	Fall	0501020303	0	9	82	0	0	0	91	0	4	0	0	0	4	0	0	0	0	
1996	Fall	0501020304	0	19	167	0	0	0	186	0	7	0	0	0	7	0	0	0	0	
1996	Fall	0501020305	0	11	195	0	0	0	206	0	13	0	0	0	13	0	0	0	0	
1996	Fall	0501020306	0	17	125	0	0	0	142	0	14	0	0	0	14	0	0	0	0	
1996	Fall	0501020307	0	4	172	0	0	0	176	0	13	0	0	0	13	0	0	0	0	
1996	Fall	0501020308	0	0	129	0	0	0	129	0	6	0	0	0	6	0	0	0	0	
1996	Fall	0501020309	0	9	69	0	0	0	78	0	3	0	0	0	3	0	0	0	0	
1996	Fall	0501020310	0	0	57	0	0	0	57	0	1	0	0	0	1	0	0	0	0	
1996	Fall	0501020311	0	5	103	0	0	0	108	0	8	0	0	0	8	0	0	0	0	
1996	Fall	0501020312	0	9	86	0	0	0	95	0	7	0	0	0	7	0	0	0	0	
1996	Fall	0501020313	0	8	75	0	0	0	83	0	5	0	0	0	5	0	0	0	0	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1996	Fall	0501020314	0	8	31	0	0	0	39	0	5	0	0	0	5	0	0	0	0	
1996	Fall	0501020315	0	0	40	0	0	0	40	0	1	0	0	0	1	0	0	0	0	
1996	Fall	0501020401	0	0	14	0	0	0	14	0	0	0	0	0	0	0	0	0	0	
1996	Fall	0501020402	0	4	13	0	0	0	17	0	0	0	0	0	0	0	0	0	0	
1996	Fall	0501020403	0	0	39	0	0	0	39	0	4	0	0	0	4	0	0	0	0	
1996	Fall	0501020404	0	0	25	0	0	0	25	0	1	0	0	0	1	0	0	0	0	
1996	Fall	0501020405	0	5	31	0	0	0	36	0	2	0	0	0	2	0	0	0	0	
1996	Late-fall	054123	48	105	532	0	0	0	685	0	54	502	0	0	556	0	0	0	0	
1996	Late-fall	054124	9	41	282	0	0	0	332	0	16	370	0	0	386	0	0	0	0	
1996	Late-fall	054125	48	141	445	0	0	0	634	0	74	741	0	0	815	0	0	0	0	
1996	Late-fall	054126	0	25	401	0	0	0	426	0	4	83	0	0	87	0	0	0	0	
1996	Late-fall	054127	10	24	350	0	0	0	384	0	0	64	0	0	64	0	0	0	0	
1996	Late-fall	054229	19	37	272	0	0	0	328	0	7	89	0	0	96	0	0	0	0	
1996	Late-fall	054230	0	0	37	0	0	0	37	0	1	7	0	0	8	0	0	0	0	
1996	Late-fall	054231	10	23	100	0	0	0	133	0	1	40	0	0	41	0	0	0	0	
1996	Late-fall	054232	0	0	1	0	0	0	1	0	2	31	0	0	33	0	0	0	0	
1996	Late-fall	054233	5	33	104	0	0	0	142	0	5	135	0	0	140	0	0	0	0	
1996	Late-fall	054234	10	94	340	0	0	0	444	0	36	357	0	0	393	0	0	0	0	
1996	Late-fall	054235	34	42	387	0	0	0	463	0	27	366	0	0	393	0	0	0	0	
1996	Late-fall	054236	14	40	272	0	0	0	326	0	18	184	0	0	202	0	0	0	0	
1996	Late-fall	054237	14	12	305	0	0	0	331	0	19	108	0	0	127	0	0	0	0	
1996	Late-fall	054238	19	85	419	0	0	0	523	0	31	451	0	0	482	0	0	0	0	
1996	Late-fall	054239	19	129	601	0	0	0	749	0	35	592	0	0	627	0	0	0	0	
1996	Late-fall	054240	14	39	341	0	0	0	394	0	14	362	0	0	376	0	0	0	0	
1996	Late-fall	054241	34	81	351	0	0	0	466	0	27	556	0	0	583	0	0	0	0	
1997	Winter	0501011512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020508	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020509	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020511	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020513	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020514	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020515	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020602	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020603	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020604	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020605	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020606	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020607	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020608	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

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				Ocean Catch							Hatchery Returns					Battle Creek				
BY	Run	Tag Code	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Age 2	Age 3	Age 4	Total	Notes
1997	Fall	0501020609	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020611	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020612	0	12	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020613	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020614	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020615	0	7	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020701	0	10	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020702	0	13	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020703	0	8	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020704	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	
1997	Fall	0501020705	0	8	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	
1997	Late-fall	055040	0	45	0	0	0	0	45	0	9	0	0	0	9	0	0	0	0	
1997	Late-fall	055041	8	35	0	0	0	0	43	0	10	0	0	0	10	0	0	0	0	
1997	Late-fall	055042	4	131	0	0	0	0	135	0	19	0	0	0	19	0	0	0	0	
1997	Late-fall	055048	0	66	0	0	0	0	66	0	17	0	0	0	17	0	0	0	0	
1997	Late-fall	055049	0	122	0	0	0	0	122	0	1	0	0	0	1	0	0	0	0	
1997	Late-fall	055050	0	11	0	0	0	0	11	0	1	0	0	0	1	0	0	0	0	
1997	Late-fall	055051	8	208	0	0	0	0	216	0	61	0	0	0	61	0	0	0	0	
1997	Late-fall	055052	4	232	0	0	0	0	236	0	65	0	0	0	65	0	0	0	0	
1997	Late-fall	055053	0	122	0	0	0	0	122	0	55	0	0	0	55	0	0	0	0	
1997	Late-fall	055054	7	133	0	0	0	0	140	0	47	0	0	0	47	0	0	0	0	
1997	Late-fall	055055	4	154	0	0	0	0	158	0	41	0	0	0	41	0	0	0	0	
1997	Late-fall	055056	0	72	0	0	0	0	72	0	13	0	0	0	13	0	0	0	0	
1997	Late-fall	055057	0	120	0	0	0	0	120	0	27	0	0	0	27	0	0	0	0	
1997	Late-fall	055058	0	68	0	0	0	0	68	0	11	0	0	0	11	0	0	0	0	
1997	Late-fall	055059	0	75	0	0	0	0	75	0	16	0	0	0	16	0	0	0	0	
1997	Late-fall	055060	0	31	0	0	0	0	31	0	2	0	0	0	2	0	0	0	0	
1997	Late-fall	055061	4	84	0	0	0	0	88	0	8	0	0	0	8	0	0	0	0	
1997	Late-fall	055062	0	93	0	0	0	0	93	0	5	0	0	0	5	0	0	0	0	
		Totals	423	20896	53910	5303	161	5	80698	2	3687	17358	3815	66	24928	71	695	251	991	
		Percents	0.52	25.89	66.80	6.57	0.20	0.01		0.01	14.79	69.63	15.30	0.26		7.1645	70.131181	25.328		

Appendix 3B. Generation of harvest estimates and associated data tables for brood years 1989-1995

Total ocean contribution has been estimated for fall, late-fall and winter chinook salmon by brood year for 1989 through 1995. These estimates were generated by first obtaining expanded coded-wire recovery data for all marked groups during those brood years from the Pacific States Marine Fisheries Commission website. Ocean harvest contribution rates were then generated for all coded-wire tag groups by dividing the number of expanded ocean recoveries by the number of marked juveniles in the release group. For production groups consisting of unmarked juveniles, contribution rates from individual marked groups, or averages of marked groups, were applied as appropriate using criteria such as similar release site or similar release size. The estimated ocean contribution rates for each run and release group are presented by age class for all three runs of salmon for brood years 1989 through 1995 in the following tables (Table 3-1 through Table 3-7).

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Table 3B-1. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1989. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	Untagged	769,343	Battle Creek	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*24*	*335*	*139*	*0*	*498*
	Untagged	3,919,302	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*121*	*1,706*	*707*	*0*	*2,535*
	052055	51,069	Battle Creek	smolt	0.000	0.051	0.025	0.000	0.076	0	26	13	0	39
	Untagged	101,722	Battle Creek	smolt	*0.000*	*0.049*	*0.021*	*0.000*	*0.070*	*0*	*50*	*22*	*0*	*71*
	052056	51,533	Below RBDD	smolt	0.000	0.047	0.017	0.000	0.064	0	24	9	0	33
	052057	52,077	Princeton	smolt	0.000	0.023	0.000	0.000	0.023	0	12	0	0	12
	Untagged	6,280,590	Princeton	smolt	*0.000*	*0.023*	*0.000*	*0.000*	*0.023*	*0*	*1,443*	*0*	*0*	*1,443*
	052058	52,446	Benicia	smolt	0.010	0.381	0.074	0.000	0.465	5	200	39	0	244
	Untagged	5,608,310	Benicia	smolt	*0.010*	*0.381*	*0.074*	*0.000*	*0.465*	*535*	*21,387*	*4,170*	*0*	*26,092*
	Total	16,886,392						Percent	0.184				Contribution	30,966
Late-Fall	052054	47,733	Battle Creek	pre-smolt	0.000	0.054	0.000	0.000	0.054	0	26	0	0	26
	052053	44,959	Battle Creek	smolt	0.013	0.018	0.000	0.000	0.031	6	8	0	0	14
	Untagged	463,932	Battle Creek	smolt	*0.013*	*0.018*	*0.000*	*0.000*	*0.031*	*62*	*83*	*0*	*0*	*144*
	Untagged	277,183	Old Mouth of	smolt	*0.013*	*0.018*	*0.000*	*0.000*	*0.031*	*37*	*49*	*0*	*0*	86
	Total	833,807						Percent	0.032			Contribution		271

Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3B-2. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1990. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	0501010110	48,656	Battle Creek	fry	0.006	0.062	0.018	0.000	0.086	3	30	9	0	42
	Untagged	2,390,322	Battle Creek	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*74*	*1,041*	*431*	*0*	*1,546*
	0501010111	51,139	Below RBDD	fry	0.000	0.025	0.018	0.000	0.043	0	13	9	0	22
	Untagged	200,018	Battle Creek	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*6*	*87*	*36*	*0*	*129*
	Untagged	271,156	Lake Redding Park	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*8*	*118*	*49*	*0*	*175*
	Untagged	550,045	Anderson Park	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*17*	*239*	*99*	*0*	*356*
	Untagged	324,679	Redding Posse Grounds	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*10*	*141*	*59*	*0*	*210*
	Untagged	307,819	Bend Bridge	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*9*	*134*	*56*	*0*	*199*
	Untagged	672,559	Balls Ferry	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*21*	*293*	*121*	*0*	*435*
	Untagged	680,214	Old Mouth of Battle Crk	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*21*	*296*	*123*	*0*	*440*
	Untagged	4,464,809	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*138*	*1,944*	*806*	*0*	*2,887*
	Untagged	666,834	Woodson Bridge	fry	*0.003*	*0.044*	*0.018*	*0.000*	0.065	*21*	*290*	*120*	*0*	*431*
	0501010113	64,373	Battle Creek	smolt	0.022	0.351	0.053	0.000	0.426	14	226	34	0	274
	0501010112	64,118	Below Red Bluff	smolt	0.048	0.449	0.087	0.000	0.585	31	288	56	0	375
	051845	12,474	Princeton	smolt	0.040	0.184	0.000	0.000	0.224	5	23	0	0	28
	051847	18,713	Princeton	smolt	0.027	0.278	0.075	0.000	0.379	5	52	14	0	71
	051848	20,792	Princeton	smolt	0.024	0.260	0.077	0.000	0.361	5	54	16	0	75
	Untagged	6,349,775	Princeton	smolt	*0.030*	*0.241*	*0.051*	*0.000*	0.322	*1,923*	*15,281*	*3,212*	*0*	*20,417*
	Untagged	218,638	Princeton	smolt	*0.030*	*0.241*	*0.051*	*0.000*	0.322	*66*	*526*	*111*	*0*	*703*
	0501010104	43,750	Benicia	smolt	0.091	1.419	0.181	0.000	1.691	40	621	79	0	740
	Untagged	901,820	Benicia	smolt	*0.091*	*1.419*	*0.181*	*0.000*	1.691	*825*	*12,801*	*1,628*	*0*	*15,254*
	Untagged	5,049,448	Benicia	smolt	*0.091*	*1.419*	*0.181*	*0.000*	1.691	*4,617*	*71,673*	*9,118*	*0*	*85,408*
	Total	23,372,151					Percent Contribution		0.557			Contribution		130,217
Late-Fall	Untagged	129,351	Battle Creek	smolt	*0.338*	*0.236*	*0.002*	*0.003*	*0.579*	*437*	*305*	*3*	*4*	*749*
	Untagged	74,036	Battle Creek	smolt	*0.338*	*0.236*	*0.002*	*0.003*	*0.579*	*250*	*174*	*1*	*2*	*428*
	Total	203,387					Percent Contribution		0.579			Contribution		1,177
Total Chinook Released		**23,575,538**					**Total Percent Contribution**		**0.557**			**Total Contribution**		**131,394**

Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3B-3. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1991. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	Untagged	10,234	Battle Creek	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*3*	*1*	*0*	*3*
	0501010310	55,053	Below RBDD	fry	0.000	0.015	0.011	0.000	0.025	0	8	6	0	14
	B50203	53,276	Below RBDD	fry	0.000	0.036	0.004	0.000	0.039	0	19	2	0	21
	Untagged	1,567,486	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*393*	*115*	*0*	*508*
	Untagged	1,902,744	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*478*	*139*	*0*	*617*
	Untagged	1,290,970	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*324*	*95*	*0*	*419*
	Untagged	2,336,797	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*586*	*171*	*0*	*758*
	Untagged	1,837,222	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*461*	*135*	*0*	*596*
	Untagged	2,025,665	Below RBDD	fry	*0.000*	*0.025*	*0.007*	*0.000*	*0.032*	*0*	*508*	*148*	*0*	*657*
	0601110206	24,862	Verona	fry	0.024	0.020	0.000	0.000	0.044	6	5	0	0	11
	0601110207	26,219	Verona	fry	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0601110208	21,253	Verona	fry	0.000	0.038	0.000	0.014	0.052	0	8	0	3	11
	0601110209	21,111	Miller Park	fry	0.000	0.000	0.000	0.014	0.014	0	0	0	3	3
	052812	54,433	Battle Creek	smolt	0.029	0.050	0.015	0.000	0.094	16	27	8	0	51
	052813	49,507	Battle Creek	smolt	0.010	0.063	0.008	0.000	0.081	5	31	4	0	40
	052814	53,886	Battle Creek	smolt	0.000	0.013	0.000	0.000	0.013	0	7	0	0	7
	Untagged	29,481	Battle Creek	smolt	*0.010*	*0.049*	*0.007*	*0.000*	*0.065*	*3*	*14*	*2*	*0*	*19*
	052818	49,373	Below RBDD	smolt	0.000	0.069	0.004	0.000	0.073	0	34	2	0	36
	052819	53,332	Princeton	smolt	0.045	0.219	0.026	0.000	0.291	24	117	14	0	155
	Untagged	5,186,955	Princeton	smolt	*0.045*	*0.219*	*0.026*	*0.000*	*0.291*	*2,334*	*11,379*	*1,362*	*0*	*15,075*
	Untagged	6,134,291	Princeton	smolt	*0.045*	*0.219*	*0.026*	*0.000*	*0.291*	*2,760*	*13,457*	*1,610*	*0*	*17,828*
	Untagged	2,464,377	Princeton	smolt	*0.045*	*0.219*	*0.026*	*0.000*	*0.291*	*1,109*	*5,406*	*647*	*0*	*7,162*
	052830	54,055	Benicia	smolt	0.061	1.315	0.213	0.000	1.589	33	711	115	0	859
	Total	25,302,582						Percent Contribution	0.177			Contribution		44,850
Late-Fall	0501010308	50,351	Battle Creek	smolt	0.242	0.189	0.004	0.006	0.441	122	95	2	3	222
	0501010309	54,840	Battle Creek	smolt	0.434	0.283	0.000	0.000	0.717	238	155	0	0	393
	Untagged	183,837	Battle Creek	smolt	*0.338*	*0.236*	*0.002*	*0.003*	*0.579*	*622*	*433*	*4*	*5*	*1,064*
	Total	289,028						Percent Contribution	0.581			Contribution		1,679
Winter	0501010403	1,733	Lake Redding Park	smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010404	1,871	Lake Redding Park	smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010405	2,934	Lake Redding Park	smolt	0.170	0.000	0.000	0.000	0.170	5	0	0	0	5
	0501010406	4,328	Lake Redding Park	smolt	0.162	0.069	0.000	0.000	0.231	7	3	0	0	10
	Total	10,866						Percent Contribution	0.138			Contribution		15
Total Chinook Released		**25,602,476**						**Total Percent Contribution**	**0.182**			**Total Contribution**		**46,544**

Due to rounding error, values displayed in total column may differ from summation of age values.

Table 3B-4. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1992. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	0501010801	54,398	Below RBDD	fry	0.088	0.627	0.077	0.013	0.805	48	341	42	7	438
	0501010802	56,721	Below RBDD	fry	0.104	0.603	0.058	0.000	0.765	59	342	33	0	434
	0501010803	59,697	Battle Creek	smolt	0.077	1.094	0.178	0.005	1.354	46	653	106	3	808
	0501010804	56,131	Battle Creek	smolt	0.196	1.969	0.118	0.005	2.288	110	1,105	66	3	1,284
	0501010805	59,440	Battle Creek	smolt	0.262	1.842	0.185	0.008	2.298	156	1,095	110	5	1,366
	0601141101	30,715	Battle Creek	smolt	0.309	1.494	0.104	0.000	1.908	95	459	32	0	586
	0601141102	28,361	Battle Creek	smolt	0.123	1.513	0.155	0.000	1.791	35	429	44	0	508
	Untagged	1,718,045	Battle Creek	smolt	*0.077*	*1.094*	*0.178*	*0.005*	*1.354*	*1,324*	*18,793*	*3,051*	*86*	*23,254*
	Untagged	1,742,036	Battle Creek	smolt	*0.077*	*1.094*	*0.178*	*0.005*	*1.354*	*1,342*	*19,055*	*3,093*	*88*	*23,578*
	Untagged	2,511,443	Battle Creek	smolt	*0.229*	*1.905*	*0.151*	*0.007*	*2.293*	*5,756*	*47,853*	*3,800*	*173*	*57,583*
	Untagged	5,599,143	Battle Creek	smolt	*0.229*	*1.905*	*0.151*	*0.007*	*2.293*	*12,834*	*106,686*	*8,473*	*385*	*128,378*
	Total	11,916,130					Percent Contribution		1.999				Contribution	238,217
Late-Fall	052859	52,245	Battle Creek	smolt	0.469	0.354	0.011	0.000	0.835	245	185	6	0	436
	052862	52,666	Battle Creek	smolt	0.463	0.237	0.000	0.000	0.701	244	125	0	0	369
	053121	62,121	Battle Creek	smolt	0.551	0.402	0.003	0.003	0.959	342	250	2	2	596
	053122	155,214	Battle Creek	smolt	0.606	0.352	0.014	0.001	0.973	940	547	21	2	1,510
	053120	13,035	Clifton Ct Forebay	smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	Total	322,246					Percent Contribution		0.903				Contribution	2,911
Winter	0501010607	3,058	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010608	1,524	N.St. Anderson	pre-smolt	0.262	0.000	0.000	0.000	0.262	4	0	0	0	4
	0501010609	1,588	N.St. Anderson	pre-smolt	1.511	0.000	0.000	0.000	1.511	24	0	0	0	24
	0501010610	1,215	N.St. Anderson	pre-smolt	0.412	0.000	0.000	0.000	0.412	5	0	0	0	5
	0501010611	1,136	N.St. Anderson	pre-smolt	1.320	0.000	0.000	0.000	1.320	15	0	0	0	15
	0501010612	880	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010613	452	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010614	2,235	N.St. Anderson	pre-smolt	0.984	0.000	0.000	0.000	0.984	22	0	0	0	22
	0501010615	221	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010701	520	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010702	698	N.St. Anderson	pre-smolt	1.003	0.000	0.000	0.000	1.003	7	0	0	0	7
	0501010703	1,458	N.St. Anderson	pre-smolt	0.412	0.000	0.000	0.000	0.412	6	0	0	0	6
	0501010704	951	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010705	924	N.St. Anderson	pre-smolt	1.082	0.000	0.000	0.000	1.082	10	0	0	0	10
	0501010706	742	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010707	90	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010708	81	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010709	1,005	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010710	1,314	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010711	1,621	N.St. Anderson	pre-smolt	0.617	0.000	0.000	0.000	0.617	10	0	0	0	10
	0501010712	2,250	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010713	2,385	N.St. Anderson	pre-smolt	0.169	0.000	0.000	0.000	0.169	4	0	0	0	4
	0501010714	1,055	N.St. Anderson	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	Total	27,383					Percent Contribution		0.391				Contribution	107
Total Chinook Released		**12,265,759**					**Total Percent Contribution**		**1.967**			**Total Contribution**		**241,235**

Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3B-5. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1993. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	Untagged	34,775	Battle Creek	fry	*0.003*	*0.061*	*0.012*	*0.000*	*0.077*	*1*	*21*	*4*	*0*	*27*
	0501010908	49,422	Below RBDD	fry	0.000	0.049	0.006	0.000	0.055	0	24	3	0	27
	0501010909	52,860	Below RBDD	fry	0.006	0.074	0.019	0.000	0.098	3	39	10	0	52
	Untagged	932,256	Below RBDD	fry	*0.003*	*0.061*	*0.012*	*0.000*	*0.077*	*26*	*570*	*116*	*0*	*713*
	Untagged	1,294,341	Below RBDD	fry	*0.003*	*0.061*	*0.012*	*0.000*	*0.077*	*37*	*792*	*162*	*0*	*990*
	Untagged	1,257,406	Below RBDD	fry	*0.003*	*0.061*	*0.012*	*0.000*	*0.077*	*36*	*769*	*157*	*0*	*962*
	Untagged	918,666	Below RBDD	fry	*0.003*	*0.061*	*0.012*	*0.000*	*0.077*	*26*	*562*	*115*	*0*	*703*
	053427	54,892	Battle Creek	smolt	0.018	0.191	0.042	0.004	0.255	10	105	23	2	140
	053428	53,430	Battle Creek	smolt	0.034	0.365	0.064	0.007	0.470	18	195	34	4	251
	053429	52,483	Battle Creek	smolt	0.107	0.579	0.097	0.004	0.787	56	304	51	2	413
	Untagged	11,959,696	Battle Creek	smolt	*0.053*	*0.378*	*0.068*	*0.005*	*0.504*	*6,323*	*45,267*	*8,081*	*596*	*60,267*
	Total	16,660,227					Percent Contribution		0.387				Contribution	64,544
Late-Fall	053316	52,985	Battle Creek	smolt	0.255	0.260	0.000	0.000	0.515	135	138	0	0	273
	053317	53,464	Battle Creek	smolt	0.088	0.110	0.015	0.000	0.213	47	59	8	0	114
	053408	67,645	Battle Creek	smolt	0.183	0.167	0.000	0.000	0.350	124	113	0	0	237
	053409	72,236	Battle Creek	smolt	0.137	0.154	0.004	0.000	0.295	99	111	3	0	213
	053410	73,882	Battle Creek	smolt	0.074	0.120	0.001	0.000	0.196	55	89	1	0	145
	053411	78,423	Battle Creek	smolt	0.055	0.134	0.004	0.000	0.193	43	105	3	0	151
	053412	69,894	Battle Creek	smolt	0.086	0.228	0.000	0.000	0.312	60	158	0	0	218
	053413	78,569	Battle Creek	smolt	0.342	0.241	0.010	0.000	0.593	269	189	8	0	466
	053414	65,609	Battle Creek	smolt	0.195	0.142	0.011	0.000	0.348	128	93	7	0	228
	053415	54,248	Battle Creek	smolt	0.192	0.210	0.004	0.000	0.406	104	114	2	0	220
	053417	12,312	Clifton CT Forebay	smolt	0.000	0.130	0.000	0.000	0.130	0	16	0	0	16
	064521	33,668	Georgiana Slough	smolt	0.092	0.143	0.000	0.000	0.235	31	48	0	0	79
	064522	34,650	Ryde-Koket	smolt	0.367	0.421	0.029	0.000	0.817	127	146	10	0	283
	Total	747,585					Percent Contribution		0.354				Contribution	2,643
Winter	0501010810	786	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010811	1,135	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010812	892	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010814	1,466	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.409	0.409	0	0	0	6	6
	0501010815	1,297	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010901	838	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010902	375	Lake Redding Park	pre-smolt	0.800	0.000	0.000	0.000	0.800	3	0	0	0	3
	0501010903	296	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010904	173	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010905	2,462	Lake Redding Park	pre-smolt	0.366	0.000	0.000	0.000	0.366	9	0	0	0	9
	0501010906	2,615	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501010907	4,690	Lake Redding Park	pre-smolt	0.106	0.106	0.000	0.000	0.213	5	5	0	0	10
	Total	17,034					Percent Contribution		0.164				Contribution	28
Total Chinook Released		**17,424,846**					**Total Percent Contribution**		**0.386**				**Total Contribution**	**67,215**

Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3B-6. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1994. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	Untagged	297,373	Battle Creek	fry	*0.004*	*0.704*	*0.076*	*0.009*	*0.793*	*13*	*2,095*	*225*	*26*	*2,359*
	Untagged	1,140,084	Balls Ferry	fry	*0.004*	*0.704*	*0.076*	*0.009*	*0.793*	*49*	*8,031*	*862*	*100*	*9,042*
	Untagged	177,473	Balls Ferry	fry	*0.004*	*0.704*	*0.076*	*0.009*	*0.793*	*8*	*1,250*	*134*	*16*	*1,408*
	0501011204	46,730	Below RBDD	fry	0.009	0.743	0.096	0.002	0.850	4	347	45	1	397
	0501011205	45,472	Below RBDD	fry	0.000	0.666	0.055	0.015	0.737	0	303	25	7	335
	Untagged	991,674	Below RBDD	fry	*0.004*	*0.704*	*0.076*	*0.009*	*0.793*	*42*	*6,986*	*750*	*87*	*7,865*
	Untagged	490,741	Below RBDD	fry	*0.004*	*0.704*	*0.076*	*0.009*	*0.793*	*21*	*3,457*	*371*	*43*	*3,892*
	0501011206	52,438	Battle Creek	smolt	0.000	0.877	0.103	0.006	0.986	0	460	54	3	517
	0501011207	49,629	Battle Creek	smolt	0.008	0.852	0.133	0.000	0.993	4	423	66	0	493
	0501011208	50,100	Battle Creek	smolt	0.000	0.571	0.118	0.000	0.689	0	286	59	0	345
	Untagged	856,320	Battle Creek	smolt	*0.008*	*0.852*	*0.133*	*0.000*	*0.993*	*69*	*7,299*	*1,139*	*0*	*8,506*
	Untagged	10,832,533	Battle Creek	smolt	*0.008*	*0.852*	*0.133*	*0.000*	*0.993*	*873*	*92,328*	*14,406*	*0*	*107,607*
	Untagged	844,457	Battle Creek	smolt	*0.000*	*0.571*	*0.118*	*0.000*	*0.689*	*0*	*4,821*	*994*	*0*	*5,815*
	Untagged	85,792	Above RBDD	smolt	*0.008*	*0.852*	*0.133*	*0.000*	*0.993*	*7*	*731*	*114*	*0*	*852*
	Untagged	217,510	Above RBDD	smolt	*0.000*	*0.571*	*0.118*	*0.000*	*0.689*	*0*	*1,242*	*256*	*0*	*1,498*
	Total	16,178,326					Percent Contribution		0.933			Contribution		150,932
Late-Fall	053620	125,754	Battle Creek	smolt	0.798	0.550	0.006	0.000	1.354	1,004	692	7	0	1,703
	053621	128,159	Battle Creek	smolt	0.375	0.617	0.017	0.000	1.009	480	791	22	0	1,293
	053622	61,673	Battle Creek	smolt	0.246	0.180	0.000	0.000	0.426	152	111	0	0	263
	053742	62,356	Battle Creek	smolt	0.273	0.172	0.000	0.000	0.444	170	107	0	0	277
	053743	62,847	Battle Creek	smolt	0.231	0.286	0.000	0.000	0.517	145	180	0	0	325
	053546	56,340	Battle Creek	smolt	0.231	0.202	0.000	0.000	0.433	130	114	0	0	244
	062524	31,557	Isleton	smolt	0.478	0.336	0.000	0.000	0.814	151	106	0	0	257
	053426	30,220	Isleton	smolt	0.050	0.043	0.000	0.000	0.093	15	13	0	0	28
	053425	31,532	Georgiannna Slough	smolt	0.019	0.016	0.000	0.000	0.035	6	5	0	0	11
	062525	31,328	Georgiannna Slough	smolt	0.188	0.131	0.000	0.000	0.319	59	41	0	0	100
	Total	621,766					Percent Contribution		0.724			Contribution		4,501

Due to rounding error, values displayed in total column may differ from summation of age values.

Table 3B-6 (cont.). Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1994. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Winter	0501011002	359	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011003	787	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011004	1,181	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011005	875	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011006	767	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011007	931	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011008	910	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011009	1,403	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011010	1,235	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011011	1,263	Bonneyview	pre-smolt	0.000	0.317	0.000	0.000	0.317	0	4	0	0	4
	0501011012	1,063	Bonneyview	pre-smolt	0.000	0.094	0.000	0.000	0.094	0	1	0	0	1
	0501011013	1,263	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011014	1,585	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011015	1,841	Bonneyview	pre-smolt	0.272	0.000	0.000	0.000	0.272	5	0	0	0	5
	0501011101	1,642	Bonneyview	pre-smolt	0.000	0.061	0.000	0.000	0.061	0	1	0	0	1
	0501011102	2,304	Bonneyview	pre-smolt	0.000	0.217	0.000	0.000	0.217	0	5	0	0	5
	0501011103	1,416	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011104	1,336	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011105	982	Bonneyview	pre-smolt	0.000	0.407	0.000	0.000	0.407	0	4	0	0	4
	0501011106	1,873	Bonneyview	pre-smolt	0.000	0.214	0.000	0.000	0.214	0	4	0	0	4
	0501011107	1,700	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011108	1,703	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011109	998	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011110	1,254	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011111	1,350	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011112	1,258	Bonneyview	pre-smolt	0.000	0.079	0.000	0.000	0.079	0	1	0	0	1
	0501011113	1,011	Bonneyview	pre-smolt	0.396	0.000	0.000	0.000	0.396	4	0	0	0	4
	0501011114	1,162	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011115	1,389	Bonneyview	pre-smolt	0.000	0.072	0.000	0.000	0.072	0	1	0	0	1
	0501011201	1,452	Bonneyview	pre-smolt	0.000	0.207	0.000	0.000	0.207	0	3	0	0	3
	0501011202	1,744	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011203	1,375	Bonneyview	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	Total	41,412					Percent Contribution		0.080			Contribution		33
Total Chinook Released		**16,841,504**					**Total Percent Contribution**		**0.923**			**Total Contribution**		**155,466**

Due to rounding error, values displayed in total column may differ from summation of age values.

Table 3B-7. Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1995. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Fall	Untagged	269,034	Battle Creek	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*8*	*117*	*49*	*0*	*174*
	Untagged	1,319,814	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*41*	*575*	*238*	*0*	*854*
	Untagged	2,520,268	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*78*	*1,097*	*455*	*0*	*1,630*
	Untagged	1,018,075	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*31*	*443*	*184*	*0*	*658*
	Untagged	900,142	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*28*	*392*	*162*	*0*	*582*
	Untagged	783,815	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*24*	*341*	*141*	*0*	*507*
	Untagged	732,473	Below Red Bluff	fry	*0.003*	*0.044*	*0.018*	*0.000*	*0.065*	*23*	*319*	*132*	*0*	*474*
	0501020114	295,384	Battle Creek	smolt	0.030	0.193	0.000	0.000	0.224	90	571	0	0	661
	0501020115	308,443	Battle Creek	smolt	0.046	0.314	0.082	0.000	0.442	141	968	254	0	1,363
	0501020201	268,960	Battle Creek	smolt	0.062	0 545	0.107	0.000	0.715	166	1,467	289	0	1,922
	Untagged	3,764,223	Battle Creek	smolt	*0.046*	*0.351*	*0.063*	*0.000*	*0.460*	*1,730*	*13,207*	*2,381*	*0*	*17,319*
	Untagged	3,787,025	Battle Creek	smolt	*0.046*	*0.351*	*0.063*	*0.000*	*0.460*	*1,741*	*13,287*	*2,396*	*0*	*17,424*
	Total	15,967,656					Percent Contribution		0.273				Contribution	43,567
Late-Fall	053416	59,136	Battle Creek	smolt	0.331	0.078	0.020	0.000	0.430	196	46	12	0	254
	053618	129,697	Battle Creek	smolt	0.723	0.128	0.000	0.000	0.851	938	166	0	0	1,104
	053627	59,566	Battle Creek	smolt	0.294	0.059	0.000	0.000	0.353	175	35	0	0	210
	053628	64,933	Battle Creek	smolt	0.505	0.063	0.017	0.000	0.585	328	41	11	0	380
	054107	74,726	Battle Creek	smolt	0.439	0.079	0.008	0.000	0.526	328	59	6	0	393
	054108	68,104	Battle Creek	smolt	0.530	0.162	0.000	0.000	0.692	361	110	0	0	471
	054109	62,091	Battle Creek	smolt	0.799	0.100	0.011	0.000	0.910	496	62	7	0	565
	054116	63,239	Battle Creek	smolt	0.267	0.044	0.008	0.000	0.319	169	28	5	0	202
	054117	67,195	Battle Creek	smolt	0.816	0.152	0.022	0.000	0.990	548	102	15	0	665
	054118	60,395	Battle Creek	smolt	0.329	0.161	0.008	0.000	0.498	199	97	5	0	301
	054119	66,808	Battle Creek	smolt	0.370	0.100	0.039	0.000	0.509	247	67	26	0	340
	054111	34,596	Port Chicago	smolt	0.662	0.101	0.000	0.000	0.763	229	35	0	0	264
	054112	34,122	Courtland	smolt	0.574	0.076	0.018	0.000	0.668	196	26	6	0	228
	054113	33,670	Georgianna Slough	smolt	0.368	0.071	0.000	0.000	0.440	124	24	0	0	148
	054114	30,281	Ryde-Koket	smolt	0.694	0.079	0.026	0.000	0.799	210	24	8	0	242
	Total	775,890					Percent Contribution		0.630				Contribution	4,885

Due to rounding error, values displayed in total column may differ from summation of age values.

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Table 3B-7 (cont.). Chinook salmon ocean contribution for coded-wire tagged groups and extrapolated ocean contribution for untagged groups for brood year 1995. Actual contribution values are displayed in regular type while extrapolated values are displayed in italics.

Run	Tag Code	Number Released	Release Site	Release Stage	% Age 2	% Age 3	% Age 4	% Age 5	Total % Contribution	Age 2	Age 3	Age 4	Age 5	Total
Winter	0501011301	1,176	Lake Redding Park	pre-smolt	0.595	0.000	0.000	0.000	0.595	7	0	0	0	7
	0501011302	1,043	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011303	1,385	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011304	643	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011305	1,515	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011306	759	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011307	1,852	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011308	1,432	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011309	1,061	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011310	1,848	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011311	1,399	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011312	1,269	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011313	1,616	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011314	1,401	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011315	1,474	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011401	1,705	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011402	1,770	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011403	1,462	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011404	93	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011405	1,276	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011406	1,043	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011407	1,694	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011408	1,563	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011409	1,602	Lake Redding Park	pre-smolt	0.312	0.000	0.250	0.000	0.562	5	0	4	0	9
	0501011410	1,057	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011411	864	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011412	2,093	Lake Redding Park	pre-smolt	0.191	0.000	0.000	0.000	0.191	4	0	0	0	4
	0501011413	1,512	Lake Redding Park	pre-smolt	0.331	0.000	0.000	0.000	0.331	5	0	0	0	5
	0501011414	1,833	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011415	1,086	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011501	1,411	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011502	1,120	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011505	3,185	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	0501011506	1,912	Lake Redding Park	pre-smolt	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0
	Total	48,154						Percent Contribution	0.052				Contribution	25
Total Chinook Released		16,791,700						Total Percent Contribution	0.289				Total Contribution	48,477

Due to rounding error, values displayed in total column may differ from summation of age values.

Appendix 3C. Analysis of adult contribution to ocean harvest resulting from Coleman National Fish Hatchery fry releases vs. smolt releases

Ocean contribution for fall chinook salmon smolts released from Coleman National Fish Hatchery (NFH) typically averages about 0.75%. The average rate of ocean contribution for all groups of fall chinook released from Coleman NFH averages about 0.4%, substantially lower than expected contribution by smolts (see Section 3, Table 3-5). This discrepancy in contribution rates is an artifact of low contribution associated with releases of fall chinook fry from Coleman NFH.

We analyzed a subset of data (brood years 1989 through 1995, Table 3A-1) for comparison against a previous analysis conducted with brood years 1980 through1987 (USFWS 1991). In comparing ocean contribution values for fry and smolt releases from brood years 1980 through 1987, an average fry to smolt survival ratio index was estimated at 4.6:1. The analysis suggests that on average, smolts survive at rates greater than four times that of fry. We also conclude in our analysis that survival of groups released as smolts contribute to ocean harvest at rates greater than those of fry (2.9 times greater if the ratios of the averages are used, or 6.7 times if the average of the ratios is used). Many other researchers have suggested the survival disadvantages exhibited by fry releases, and this has been throughly explained by the Service in 1999 (i.e., letter to Congressman Herger).

In response to the survival disadvantage of fry releases coupled with their high potential for interaction with naturally-produced fall chinook salmon fry, the Service discontinued the release of fall chinook fry from Coleman NFH in1999. Table 3C-1 clearly defines the annual average contribution difference between fry and smolts in terms of adults contributing to the ocean harvest. For brood years 1989 through 1995, fry releases contributed about 7,000 adults annually to the ocean harvest, while smolts contributed in excess of 93,000 adults annually. On average in recent years, Coleman NFH fall chinook salmon have contributed roughly 20% of the ocean harvest, and 93% (93,000/100,000) of that harvest is due to smolt releases, the average annual loss in ocean contribution due to the cessation of the stocking of fry can be measured as: 0.2 - (0.2 * 0.93) = 0.0186. By this measure, only 1.9% of the ocean harvest was made up of adults originating from fry releases.

Table 3C-1. Estimated ocean contribution for Coleman National Fish Hatchery fall chinook fry and smolt by brood year, 1989 through1995.

Brood Year	Fry Released	Contribution	Percent Contribution	Smolt Released	Contribution	Percent Contribution
1989	4,688,645	3,032	0.065	12,177,747	27,934	0.229
1990	10,628,250	6,873	0.065	12,743,901	123,344	0.968
1991	11,172,892	3,617	0.032	14,129,690	41,233	0.292
1992	111,119	872	0.785	11,805,011	237,345	2.011
1993	4,539,726	3,474	0.077	12,120,501	61,071	0.504
1994	3,189,547	25,298	0.793	12,988,779	125,634	0.967
1995	7,543,621	4,878	0.065	8,424,035	38,689	0.459
	41,873,800	48,045	0.115	84,389,664	655,249	0.776
Average	5,981,971	6,864	0.269	12,055,666	93,607	0.776
STD	4,020,564.18	8,330.53	0.36	1,775,604.21	74,945.71	0.62

Appendix 3D. Ecological impacts of over-escapement of fall chinook salmon on Battle Creek

As part of a series of reports on Battle Creek completed by Thomas Payne and Associates for the California Department of Fish and Game, Hankin (1991) investigated the interactions of hatchery- and naturally-produced fall chinook salmon in Battle Creek. In the report, Hankin attempted to: 1) determine if annual returns of Coleman National Fish Hatchery (NFH) chinook salmon could be expected to exceed those necessary for annual hatchery production needs–(excess fish could be allowed to spawn naturally in Battle Creek); 2) could a self-sustaining population of fall chinook salmon be established in Battle Creek and would continued supplementation with hatchery stock be necessary; and 3) identify possible genetic concerns and/or potential conflicts between hatchery and natural production.

Hankin (1991) analyzed contemporary data on harvest and escapement and concluded that, given that given a 65% ocean harvest rate and a 10% freshwater exploitation rate, a natural population could maintain itself in Battle Creek only if stock productivity was high, (i.e. high survival rates). He stated that continued supplementation by excess hatchery adults would be required however, to take full advantage of all natural production possible in Battle Creek. Hankin estimated that in releasing 12 million fall chinook salmon smolts, broodstock needs (7,000) would be exceeded in most years. In regard to excess fish to broodstock needs, he stated that no excess fish might be available about 1 of every 9 years and few (less than 3,500 excess) might be available as frequently as every other year. Concurrent with the escapement figures, Hankin calculated an annual ocean harvest of 48,000 adults would, on average be met, and in many years would be substantially exceeded.

In examining Hankin's conclusions, plus additional data from recent years, we find that freshwater escapement of fall chinook to Battle Creek since the mid-1990's has regularly exceeded Hankin's projections, apparently resulting from increased survival of hatchery-origin fish (see sections 3.6 and 3.8) (for comparison to Hankins (1991) projections, see Appendix 3-E where we present a model to predict ocean harvest and freshwater returns based on more-recent harvest and escapement data). Broodstock collection goals for fall chinook salmon have been consistently achieved over the past 20 years (Figure 3D-1), and ample numbers of adults have been allowed to remain in the creek to spawn naturally. Due to this increased natural spawning of hatchery adults, we suspect that there is annual contribution of naturally-spawned fall chinook salmon adults in Battle Creek. However, due to low marking rates of juvenile fall chinook at Coleman NFH, reliable differentiation of hatchery and natural origin fall chinook salmon is not currently possible[1].

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[1] Recent speculation regarding the ratio of hatchery : natural fall chinook salmon in Battle Creek are 10% natural-origin ; 90% hatchery-origin (USFWS 1995,CDFG 1994 as cited in CH2M Hill 1999, Ward and Kier 1999).

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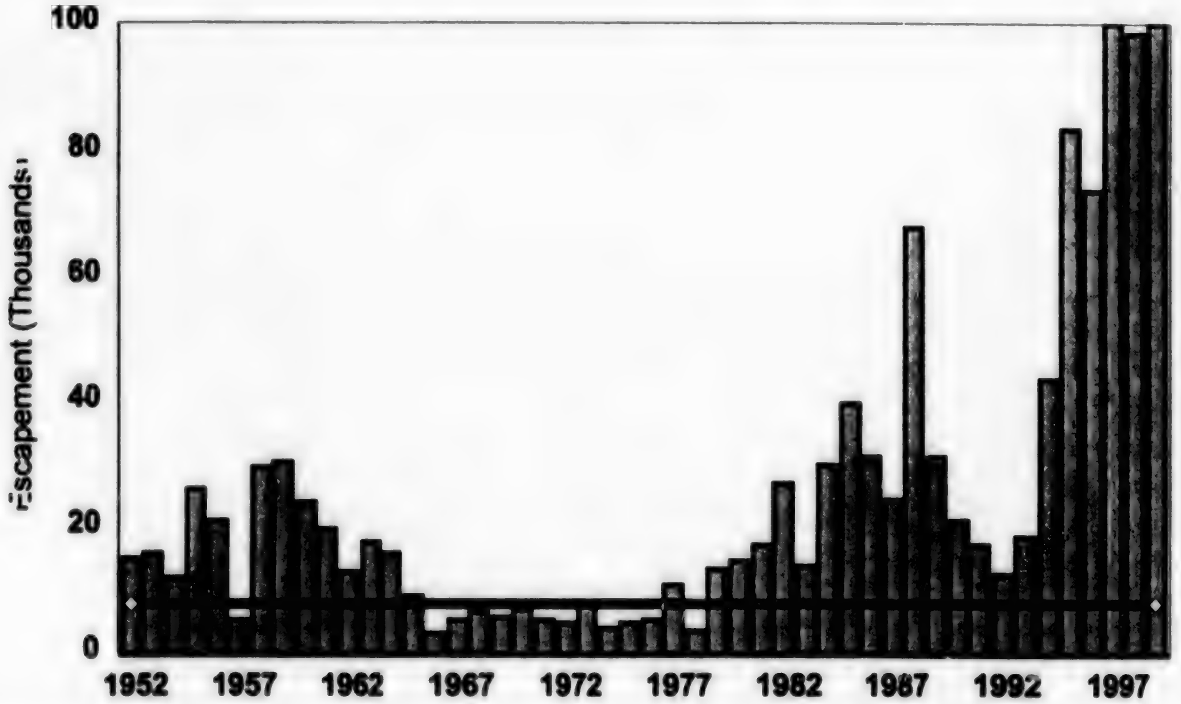

Figure 3D-1. Escapement of fall chinook salmon to Battle Creek from 1952 - 1999 (source CDFG GrandTab). Escapement includes both adults taken into Coleman National Fish Hatchery (NFH) and adults spawning naturally in Battle Creek. Heavy black line denotes broodstock collection requirement for fall chinook salmon at Coleman NFH.

Impacts of hatchery-origin fall chinook salmon on natural productivity in lower Battle Creek
Spawning habitat in the mainstem of Battle Creek has been identified as primary limiting factor for fall chinook salmon (Ward and Kier 1999). The presumed habitat capacity in lower Battle Creek has been estimated at roughly 5,000 adults. When adults are in excess of 5,000 there is a concern of reduced productivity due to spatial competition for redd sites and the potential for redd superimposition. As discussed above, it is not a question as to the origin of fish that spawn in the creek (i.e., hatchery or natural), as they are likely genetically similar.

A spawning population of 5,000 fall chinook salmon adults in Battle Creek is expected to produce approximately 3.1 million fry and eventually 1.8 million smolts. In 1999, juvenile emigration monitoring in lower Battle Creek led to a production estimate of over 14 million brood year 1998 fall chinook salmon (conservatively assumed here to be fry) (CH2M Hill 2001, USFWS RBFWO, unpublished data). Assuming a one-to-one male:female ratio, 5,000 eggs/female[2], and 75% egg-to-fry mortality rate[3], the number of contributing adults can be back-calculated at approximately 22,000 (11,000 females and 11,000 males). Therefore, although over escapement to Battle Creek did in fact occur in 1998 (estimated number in Battle Creek = 49,000), full habitat utilization was apparently achieved and juvenile production was substantially greater than anticipated. Data are similar for brood year 1999 fall chinook salmon. The juvenile production estimate was over 26 million (USFWS RBFWO, unpublished data). By our estimate, this equates to production of over 40,000 adults. Therefore, in both years, estimates of juvenile production were greater than expected production at adult carrying capacity. These data demonstrate that lower Battle Creek remains highly productive for naturally-produced fall chinook salmon juveniles despite substantial over escapement of fall chinook salmon adults.

Other concerns associated with over escapement of adults chinook to Battle Creek have also been raised including 1) increased risk of disease exposure of and transmission to juvenile salmonids from large numbers of adult carcasses infected by the infectious hematopoeitic necrosis virus (IHNV), and 2) increased biological oxygen demand resulting from the decomposition of large numbers of carcasses causing decreases in numbers of outmigrating fry. While large numbers of fall chinook salmon (and therefore carcasses) have been found in Battle Creek, no evidence of increased disease transmission has been found (see Section 10.5 for a discussion of disease management for juvenile releases). Likewise, increased biological oxygen demand resulting from the decomposition of large numbers of carcasses has not been demonstrated to decrease the concentration of dissolved oxygen in lower Battle Creek.

Numerous studies suggest salmon carcasses are a major vector for nutrient cycles and pathways (Bilby et al. 1996, Cederholm et al. 1999, Wipfli et al. 1999). Spawning salmon are known to provide marine-derived nutrients to aquatic systems, contributing to an increase in the overall productivity of the stream system. Additionally, decaying salmon carcasses are directly consumed by many invertebrates and vertebrates, enhancing both freshwater and riparian food webs (Cederholm et al. 1989, Bilby et al. 1996, Wipfli et al. 1998). Carcasses buried in the hyporheic zone form spates and may build "nutrient capitols" which serve as longer-term nutrient sources (Wipfli 1999). Because of the nutrient benefits resulting from salmon carcasses, the Washington Department of Fish and Wildlife has created policies to maximize the level of nutrient enrichment, under the assumption that overall ecosystem health will presumably benefit from having the largest number of spawners possible (WDFW 1997 cited through Cederholm 1999).

Fall chinook spawners below the Coleman barrier weir provide hundreds of tons of energy-rich salmon tissue to the Battle Creek and upper Sacramento River. More spawners translate into more decaying carcasses, which in turn translate into more energy-rich detritus (Mathiesen et al. 1998 in Wipfli et al. 1999). Invertebrate scavengers and detritivores break down the detritus providing more prey for salmonids and other fishes. More freshwater prey should support faster growing and larger juvenile salmonids, decreasing time until smoltification, and elevated survival and return as adults.

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[2] Based on average fecundity of fall chinook salmon at Coleman NFH

[3] Based on survival estimates developed for winter chinook salmon and used in the winter chinook Juvenile Production Estimate (JPE)

Based on examination of available information, we conclude that substantial over-escapement of fall chinook salmon adults into the Battle Creek watershed has likely not resulted in substantial negative impacts to juvenile productivity. To the contrary, juvenile production estimates during 1998 and 1999 greatly exceeded estimates of carrying capacity for a natural (not hatchery-affected) system. Other concerns that have been raised in association with over-escapement of hatchery adults to Battle Creek, including increased disease transmission and decreased water quality resulting from abundant salmon carcasses, also lack scientific evidence of negative impacts. To the contrary, we believe that substantial biomass of salmon carcasses in lower Battle Creek has likely served to enhance overall productivity of Battle Creek and the upper Sacramento River.

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Appendix 3E. Model of contribution of fall chinook salmon to ocean and freshwater harvests

We have constructed a model (Table 3E-1) to predict ocean and freshwater harvest, returns to Battle Creek, and strays as a function of the number of fall chinook salmon released into Battle Creek. This model can be used to predict impacts on harvest and escapement resulting from increases or decreases in fall chinook salmon juvenile (smolt) production at Coleman NFH. We provide this model as a decision making tool to assist estimations of changes in adult abundance and destination associated with various levels of fall chinook salmon production. The model could be further refined with future data and a more rigorous examination of existing data. The current model was developed using high, low and average ocean harvest contribution data from the seven most recent years of complete data. Escapement is modeled using 2:1 catch:escapement ratios (ocean harvest/ (ocean harvest + Battle Creek escapement)). In-river harvest calculated at 25% of freshwater entry, and the strays are calculated by using a stray rate of 10% of adults returning to Battle Creek (see section on straying for the generation of the stray index/rate). Based on a release of 12 million fall chinook salmon smolts, between 27,000 to 221,000 adults are expected to contribute to the ocean harvest (average = 90,000) assuming effort remains constant. At this release level we also expect 14,000 to 121,000 escaping to Battle Creek; while an additional 3,000 to 28,000 may contribute to in-river harvest.

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Table 3E-1. Potential outcomes of various levels of Coleman National Fish Hatchery fall chinook salmon smolt production on ocean harvest and freshwater returns, based on model assumptions. Shaded area denotes current production level.

Smolts Released	Estimated Ocean Harvest Contribution Rate based on Recent Seven Year Contribution Rates (%)[a]			Estimated Battle Creek (BC) Escapement based on catch: BC escapement equals 2:1			Estimated in-river Harvest based on 33.3% of Battle Creek Escapement[b]			Estimated Strays to the Sacramento River based on 11.1% of Battle Creek Escapement[c]		
	(low) 0.229	(average) 0.776	(high) 2.011									
15,000,000	34,350	116,400	301,650	17,175	58,200	150,825	5,719	19,381	50,225	1,906	6,460	16,742
14,000,000	32,060	108,640	281,540	16,030	54,320	140,770	5,338	18,089	46,876	1,779	6,030	15,625
13,000,000	29,770	100,880	261,430	14,885	50,440	130,715	4,957	16,797	43,528	1,652	5,599	14,509
12,000,000	27,480	93,120	241,320	13,740	46,560	120,660	4,575	15,504	40,180	1,525	5,168	13,393
11,000,000	25,190	85,360	221,210	12,595	42,680	110,605	4,194	14,212	36,831	1,398	4,737	12,277
10,000,000	22,900	77,600	201,100	11,450	38,800	100,550	3,813	12,920	33,483	1,271	4,307	11,161
9,000,000	20,610	69,840	180,990	10,305	34,920	90,495	3,432	11,628	30,135	1,144	3,876	10,045
8,000,000	18,320	62,080	160,880	9,160	31,040	80,440	3,050	10,336	26,787	1,017	3,445	8,929
7,000,000	16,030	54,320	140,770	8,015	27,160	70,385	2,669	9,044	23,438	890	3,015	7,813
6,000,000	13,740	46,560	120,660	6,870	23,280	60,330	2,288	7,752	20,090	763	2,584	6,697
5,000,000	11,450	38,800	100,550	5,725	19,400	50,275	1,906	6,460	16,742	635	2,153	5,581
4,000,000	9,160	31,040	80,440	4,580	15,520	40,220	1,525	5,168	13,393	508	1,723	4,464

a See Section 3, Appendix 3C, Table 1, for generation of ocean contribution rates of Coleman National Fish Hatchery fall chinook salmon smolts.

b Results in a 25% inriver harvest rate as per PFMC (1999).

c Results in a 10% stray rate (see Section 3, Appendix 3A).

Appendix 4A. Worksheets showing derivation of estimates of juvenile take resulting from water diversions for Coleman National Fish Hatchery from Battle Creek

Appendix Table 4A-1. Worksheet showing Battle Creek flow and expected water diversions at Coleman NFH Intakes 2 and 3 used to derive numerical take estimates resulting from hatchery water diversions from Battle Creek .

Bi-weekly	Battle Creek	Coleman NFH	Downstream	Total CNFH	Expected Diversion (cfs)		Percent of Battle Creek Flow Diverted		Percent of time
Period	Flow (cfs)	Water Demand (cfs)	Water Rights (cfs)	Diversion (cfs)	Intake 1 and 2	Intake 3	Intake 3	Intake 2	Intake 2
Jan 1-15	727	106	13	119	72	47	0.0645	0.0990	0.0260
Jan 16 -31	727	60	13	73	72	1	0.0014	0.0990	0.0260
Feb 1-15	693	91	13	104	72	32	0.0466	0.1039	0.0260
Feb 16 - 28	693	88	13	101	72	29	0.0413	0.1039	0.0260
Mar 1 -15	713	98	13	111	72	39	0.0541	0.1010	0.0260
Mar 16 - 31	713	78	13	91	72	19	0.0271	0.1010	0.0260
Apr 1-15	625	71	13	84	72	12	0.0187	0.1152	0.0260
Apr 16-30	625	73	13	86	72	14	0.0221	0.1152	0.0260
May 1-15	578	11	13	24	24	0	0.0000	0.0415	0.1431
May 16-31	578	21	13	34	34	0	0.0007	0.0588	0.1431
Jun 1-15	475	26	13	39	39	0	0.0006	0.0821	0.1431
Jun 16-30	475	32	13	45	45	0	0.0002	0.0947	0.1431
July 1-15	318	31	13	44	44	0	0.0006	0.1384	0.0260
July16-31	318	45	13	58	58	0	0.0000	0.1824	0.0260
Aug 1-15	256	40	13	53	53	0	0.0003	0.2070	0.0260
Aug16-31	256	47	13	60	60	0	0.0000	0.2344	0.0260
Sept 1-15	255	69	13	82	72	10	0.0376	0.2824	0.0260
Sept 16-30	255	78	13	91	72	19	0.0726	0.2824	0.0260
Oct 1-15	296	101	13	114	72	42	0.1411	0.2432	0.0260
Oct 16-31	296	102	13	115	72	43	0.1449	0.2432	0.0260
Nov 1-15	420	102	13	115	72	43	0.1035	0.1714	0.0260
Nov 16-30	420	101	13	114	72	42	0.1003	0.1714	0.0260
Dec 1-15	559	101	13	114	72	42	0.0753	0.1288	0.0260
Dec 16-31	559	104	13	117	72	45	0.0809	0.1288	0.0260

Table 4A-2. Estimated take of juvenile salmonids from Coleman Intakes 2, 3, and total take from Battle Creek resulting from water diversions into Coleman NFH. Juvenile take will occur as entrainment or impingement. Numerical take estimates do not include fishes salvaged from the hatchery's water supply system.

	Intake 2					Intake 3					Total take				
Bi-weekly Period	Fall Chinook	Late-fall Chinook	Winter Chinook	Spring Chinook	Steelhead Trout	Fall Chinook	Late-fall Chinook	Winter Chinook	Spring Chinook	Steelhead Trout	Fall Chinook	Late-fall Chinook	Winter Chinook	Spring Chinook	Steelhead Trout
Jan 1-15	115	0	0	0	0	2,883	0	0	0	0	2,883	0	0	0	115
Jan 16-31	1,420	0	0	0	11	775	0	0	0	6	775	0	11	0	1,426
Feb 1-15	592	0	0	0	1	10,222	0	0	0	21	10,222	0	1	0	613
Feb 16 - 28	227	0	0	2	37	3,473	0	0	34	571	3,475	0	37	34	798
Mar 1 -15	9	0	0	0	1	188	0	0	4	18	188	0	1	4	28
Mar 16 - 31	4	0	0	3	10	45	0	0	34	107	48	0	10	34	111
Apr 1-15	3	40	0	2	15	20	247	0	15	93	23	247	15	55	96
Apr 16-30	14	16	0	48	9	101	115	0	355	63	149	115	9	371	77
May 1-15	110	0	0	29	334	0	0	0	0	0	29	0	334	0	110
May 16-31	45	0	0	0	921	4	0	0	0	72	4	0	921	0	117
Jun 1-15	0	0	0	0	1,720	0	0	0	0	87	0	0	1,720	0	87
Jun 16-30	0	0	0	0	192	0	0	0	0	2	0	0	192	0	2
July 1-15	0	17	0	0	25	0	3	0	0	4	0	3	25	17	4
July16-31	0	22	4	0	2	0	0	0	0	0	0	4	2	22	0
Aug 1-15	0	0	21	0	5	0	0	1	0	0	0	21	6	0	0
Aug16-31	0	0	16	0	3	0	0	0	0	0	0	16	3	0	0
Sept 1-15	0	0	109	0	10	0	0	560	0	52	0	109	570	0	52
Sept 16-30	0	0	109	0	3	0	0	1,079	0	33	0	109	1,063	0	33
Oct 1-15	0	0	17	0	9	0	0	371	0	194	0	17	379	0	194
Oct 16-31	0	104	17	0	78	0	2,382	380	0	1,781	0	2,398	458	104	1,781
Nov 1-15	0	24	6	1	20	0	567	136	12	474	1	573	156	37	474
Nov 16-30	0	0	0	2	6	0	0	0	42	138	2	0	6	42	138
Dec 1-15	4	0	0	4	0	97	0	0	95	0	102	0	0	95	4
Dec 16-31	8	0	0	0	0	197	0	0	0	0	197	0	0	0	8
TOTAL	2,552	223	299	92	3,413	18,005	3,313	2,527	592	3,717	18,097	3,612	5,940	814	6,269

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Appendix Table 4A-3. **Expected proportion of emigration occurring during bi-weekly periods for fall, late-fall, winter, and spring chinook and steelhead trout in Battle Creek.**

Bi-weekly Period	Fall Chinook	Late-fall Chinook	Winter Chinook	Spring Chinook	Steelhead Trout
Jan 1-15	0.0477	0.0000	0.0000	0.0000	0.0000
Jan 16-31	0.5880	0.0000	0.0000	0.0000	0.0113
Feb 1-15	0.2338	0.0000	0.0000	0.0000	0.0012
Feb 16 - 28	0.0896	0.0000	0.0000	0.0321	0.0357
Mar 1 -15	0.0037	0.0000	0.0000	0.0031	0.0009
Mar 16 - 31	0.0018	0.0000	0.0000	0.0482	0.0102
Apr 1-15	0.0011	0.2657	0.0000	0.0319	0.0128
Apr 16-30	0.0049	0.1042	0.0000	0.6224	0.0074
May 1-15	0.0197	0.0000	0.0000	0.1891	0.1452
May 16-31	0.0057	0.0000	0.0000	0.0000	0.2825
Jun 1-15	0.0000	0.0000	0.0000	0.0000	0.3783
Jun 16-30	0.0000	0.0000	0.0000	0.0000	0.0367
July 1-15	0.0000	0.0945	0.0000	0.0040	0.0177
July16-31	0.0000	0.0945	0.0200	0.0000	0.0012
Aug 1-15	0.0000	0.0000	0.0900	0.0000	0.0024
Aug16-31	0.0000	0.0000	0.0600	0.0000	0.0012
Sept 1-15	0.0000	0.0000	0.3400	0.0000	0.0035
Sept 16-30	0.0000	0.0000	0.3400	0.0000	0.0012
Oct 1-15	0.0000	0.0000	0.0600	0.0000	0.0035
Oct 16-31	0.0000	0.3308	0.0600	0.0000	0.0318
Nov 1-15	0.0000	0.1103	0.0300	0.0046	0.0118
Nov 16-30	0.0000	0.0000	0.0000	0.0161	0.0035
Dec 1-15	0.0014	0.0000	0.0000	0.0486	0.0000
Dec 16-31	0.0026	0.0000	0.0000	0.0000	0.0000

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Appendix 6A. Summary of chinook salmon spawning at Coleman and Livingston Stone National Fish Hatcheries including brood year, run (race), collection location, capture and spawning dates, number of males, females, and jacks collected and spawned, number of eggs collected, and lot number. Information in this table may be cross-tabulated with distribution data (Appendix 10A) using "lot number" as an index field.

Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1909	FCS	BC Racks						10/26/09	11/21/09	1,250		7,568,985	
1910	FCS	BC Racks						10/25/10	12/01/10	2,588		15,446,515	
1911	FCS	BC Racks						10/25/11	12/22/11	1,653		11,590,000	
1912	FCS	BC Racks						10/25/12	12/05/12	887		6,604,000	
1913	FCS	BC Racks						10/27/13	12/15/13	2,400		16,424,310	
1914	FCS	BC Racks						10/21/14	11/30/14	3,681		22,895,000	
1915	FCS	BC Racks						10/26/15	12/02/15	1,800		11,147,060	
1916	FCS	BC Racks						10/19/16	12/08/16	2,419		14,295,000	
1917	FCS	BC Racks						10/25/17	12/05/17	844		5,977,000	
1918	FCS	BC Racks						10/24/18	12/18/18	782		5,384,000	
1919	FCS	BC Racks						10/25/19	12/17/19	619		4,078,000	
1920	FCS	BC Racks						10/20/20	11/21/20	342		2,450,000	
1921	FCS	BC Racks						10/22/21	12/03/21	578		5,840,000	
1922	FCS	BC Racks						10/21/22	11/28/22	288		1,704,000	
1923	FCS	BC Racks						10/25/23	12/04/23	248		1,620,400	
1924	SCS	Coleman Powerhouse						latter part of Sept., 1924		98		446,000	
1924	FCS	BC Racks						10/23/24	12/01/24	158		687,500	
1925	FCS	BC Racks						10/23/25	12/05/25	259		1,785,100	
1925	FCS	Mill Creek Station										60,000	
1926	FCS	BC Racks and Sacramento River						10/19/26	12/01/26	576		4,004,600	
1926	FCS	Mill Creek Station										960,000	
1927	FCS	BC Racks and Sacramento River						10/23/27	11/28/27	318		2,373,200	
1928	FCS	BC Racks and Sacramento River						10/23/28	11/27/28	312		2,347,200	
1929	FCS	BC Racks						10/22/29	12/06/29	1,066		7,674,800	
1930	FCS	BC Racks						10/26/30	11/26/30	1,419		11,130,800	
1931	FCS	BC Racks						10/24/31	12/01/31	1,096		9,941,600	
1932	FCS	BC Racks						10/27/32	11/30/32	526		4,169,000	
1933	FCS	BC Racks						10/27/33	11/28/33	179		1,452,600	
1934	FCS	BC Racks						10/25/34	11/26/34	461		2,884,000	
1935	FCS	BC Racks						10/23/35	12/04/35	1,565		8,580,700	
1936	FCS	BC Racks			6,106*	535	5,417	11/02/36	12/08/36	525	154	3,234,205	
1937	FCS	BC Racks						11/01/37	11/19/37	1,359		8,039,960	
1938	FCS	BC Racks			3,915	2,071	215	11/01/38	11/28/38	1,834	1,826	12,001,000	
1939	FCS	BC Racks			14,861	1,179	12,695	10/30/39	12/04/39	847	937	5,223,636	
1939	SCS	BC Racks						10/02/39	10/19/39	29		173,000	

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Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1940	FCS	BC Racks			4,088	2,445	316	10/31/40	11/30/40	2,383	1,325	12,204,000	
1941	FCS	BC Racks			2,606	1,733	187	10/31/41	11/25/41	1,683	736	8,088,000	
1942	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1943	SCS	Battle Creek	09/12/43	10/20/43								934,802	
1943	SCS	Balls Ferry & Keswick	09/12/43	10/20/43								118,863	
1943	FCS	Balls Ferry	10/20/43	11/29/43								8,320,853	
1944	SCS	Battle Creek	09/18/44	10/25/44								476,666	
1944	SCS	Balls Ferry & Keswick	09/18/44	10/25/44								3,563,984	
1944	FCS	Balls Ferry	10/18/44	11/20/44								11,298,880	
1945	SCS	BC Racks	09/16/45	10/22/45	462			09/27/45	10/15/45	31		127,668	8
1945	SCS	Balls Ferry	09/16/45	10/22/45				09/26/45	10/26/45	220		1,153,604	9
1945	FCS	Balls Ferry & Keswick	10/13/45	11/29/45				10/13/45	12/15/45	3,004		20,579,463	10
1945	FCS	BC Racks						12/13/45	01/21/46	200		3,256,000	11
1945	FCS	BC Racks										10,444,000	12
1946	SCS	Keswick	06/01/46	10/04/46	2,391					236		1,287,000	13
1946	SCS	BC Racks	June		2,450			09/23/46	10/15/46	333		1,476,000	12
1946	FCS	Keswick	11/04/46	11/26/46	7,536	2,385		11/06/46	12/05/46	2,379		14,403,000	15
1946	FCS	BC Racks & Diversion into Station	10/08/46	11/07/46	10,831	2,076		10/08/46	11/20/46	1,801		10,775,000	14
1947	SCS	BC Racks	06/13/47	09/26/47	1,003			09/16/47	10/06/47	38	16	165,000	17
1947	FCS	BC Racks & Diversion into Station	10/01/47	12/05/47	16,151 (est.)		5,324	10/21/47	12/06/47	1,947	528	10,875,000	18
1948	FCS	Keswick	10/16/48	10/30/48	102	27		12/16/48	12/30/48	27	25	150,000	
1948	FCS	BC Racks	10/06/48	11/30/48	2,374	794	1,259	10/28/48	11/30/48	674	219	3,770,000	19
1948	SCS	BC Racks	06/28/48	09/22/48	55		34					No Eggs Collected	
1949	FCS	BC Racks	10/01/49	12/12/49	5,528	2,391	1,835	10/20/49	12/12/49	2,221	782	13,221,464	23
1949	SCS	BC Racks	09/01/49	10/17/49	112	42	21	10/07/49	10/17/49	40	30	206,513	22
1950	FCS	Keswick	11/06/50	12/22/50	1,149	532	233			506	196	3,152,155	28
1950	SCS	BC Dam & Ponds			830	194	314	10/01/50	10/23/50	153	105	870,469	27
1950	FCS	BC Racks			4,105	1,604	1,669	10/22/50	12/18/50	1,384	492	7,438,254	28
1951	SCS	BC Dam & Ponds	09/18/51	11/20/51	1,632	168	1,464	09/18/51	10/19/51	158	94	966,926	32
1951	FCS	BC Racks			9,506	3,151	5,190			2,856	796	17,307,719	33
1951	FCS	Keswick	11/13/51	12/03/51	3,006	953	1,127	11/13/51	12/07/51	926	330	5,806,824	33
1952	FCS	BC Racks & Dam/Ponds	09/26/52	11/26/52	11,459	3,902	3,880	09/22/52	12/10/52	3,607	979	20,074,443	38
1952	FCS	Keswick	11/18/52	12/05/52	4,661	2,369	653	11/19/52	12/19/52	2,097	556	14,248,478	38
1953	FCS	BC Racks & Dam/Ponds	10/01/53	11/18/53	12,498	4,763	4,641	09/30/53	12/08/53	4,336	763	26,552,505	43
1953	FCS	Keswick	11/16/53	12/09/53	8,221	3,316	1,276	11/18/53	12/17/53	2,750	464	18,231,873	43

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Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1954	FCS							09/01/54	11/01/54				45
1954	FCS	BC Racks & Dam/Ponds	10/01/54	11/16/54	7,812	2,248	3,179	09/30/54	12/22/54	2,091	569	11,191,249	46
1954	FCS	Keswick	11/15/54	12/15/54	5,997	2,389	1,480	11/18/54	12/23/54	2,160	627	12,308,482	
1955	FCS	BC Dam & Ponds	09/14/55	01/16/56	10,576			09/30/55	01/16/56	4,929 BC & Kes combined	1,316 BC & Kes combined	15,906,918	5CM
1955	FCS	Keswick	11/17/55	12/19/55	6,450			11/18/55	01/09/56			13,605,710	5CM
1955	WCS	Keswick	03/22/55	04/02/55	184					2			
1956	FCS	BC Dam & Ponds	09/21/56	01/21/57	7,358			10/04/56	01/21/57	3,606 BC & Kes combined	873 BC & Kes combined	15,042,946	6CM
1956	FCS	Keswick	11/19/56	12/27/56	2,641			11/20/56	01/21/57			6,551,079	6CM
1957	FCS	BC Dam & Ponds	09/30/57	02/26/58	3,045			10/04/57	02/10/58	2,889 BC & Kes combined	662 BC & Kes combined	4,105,534	7CM-56
1957	FCS	Keswick	11/14/57	01/13/58	9,111			11/15/57	01/27/58			15,154,263	11MT
1958	WCS	BC Dam & Ponds	04/23/58	06/16/58	309				06/16/58	146		381,165 (BC & Kes)	8-CM-60
1958	FCS	BC Dam & Ponds	09/16/58	02/04/59	15,671			10/06/58	02/04/59	3,629		19,681,398	8-CM-62
1958	WCS	Keswick	04/21/58	05/26/58	420			04/25/58	05/23/58	90		381,165 (BC & Kes)	
1958	FCS	Keswick	11/17/58	02/16/59	9,373			11/20/58	02/16/59	2,916		17,268,438	8-CM-62
1958	FCS	Klamath River			8,024							220,800	
1958	FCS	Nimbus										51,840	8-CAL-64
1959	FCS	BC Dam & Ponds	09/28/59	01/29/60	10,863	5,903	824	09/28/59	01/29/60			33,474,000	9-CM-56
1959	FCS	Keswick	11/16/59	01/29/60	7,566	3,402	605	11/17/59	01/29/60	3,093		19,169,000	9-CM-66
1960	FCS	BC Dam & Ponds	09/13/60	01/16/61	9,605		3,866	10/05/60	01/16/61	2,706		18,612,000	9-CM-74
1960	FCS	Keswick	11/16/60	01/09/61	9,859		2,320	11/17/60	01/23/61	3,429		21,900,000	9-CM-74
1960	FCS	Spring Creek, WA										306,936	0-SC-73
1960	FCS	Fall Creek										40,113	0-CAL-75
1960	FCS	Nimbus										111,679	0-CAL-75
1961	FCS	BC Dam & Ponds	09/28/61	01/24/62	8,603	3,661	1,845	10/06/61	01/24/62	3,475		22,221,000	1-CN-78
1961	FCS	Keswick	11/15/61	01/05/62	5,647	2,558	427	11/17/61	01/15/62	2,263		13,315,000	1-CN-78
1961	FCS	Klamath River										100,800	1-CAL-79
1961	FCS	Nimbus										120,000	1-CAL-79
1961	WCS	Keswick	05/01/61	05/06/61									
1962	FCS	BC Dam & Ponds	10/01/62	12/31/62	4,761		1,356	10/08/62	03/05/63	1,645		9.125,000(Incomplete)	2-CN-83
1962	FCS	Keswick	11/13/62		10,589	4,078	1,416	11/14/62	03/05/63	3,131		17,181,000 (Incomplete)	2-CN-83
1962	WCS (LFS)	Keswick										60,000	1-CN-82
1962	WCS	Keswick	04/30/62	06/07/62	63								
1963	WCS	Keswick	05/22/63	07/12/63	514			05/23/63	07/12/63	53		235,700	3-CN-88
1963	FCS	BC Dam & Ponds	10/03/63	04/14/64	5,114			10/07/63	02/18/64	2,356		14,500,000	4-CN-89
1963	FCS	Keswick	11/17/63	03/24/64				11/17/63	03/24/64	2,105		13,500,000	4-CN-89

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Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1964	WCS	Keswick	05/31/64	06/29/64	15								
1964	FCS	BC Dam & Ponds	10/01/64	03/22/65	3,873			10/08/64	01/18/65	1,585		10,103,500	5-CN-93
1964	FCS	Keswick	11/26/64	03/16/65	2,769			11/30/64	03/16/65	1,239		8,053,500	5-CN-93
1964	FCS	Nimbus										10,588,500	5-CAL-94
1965	WCS	Keswick	06/14/65	06/30/65	48			06/21/65	07/01/65	16	6	60,000	
1965	FCS	BC Dam & Ponds	10/05/65	03/07/66	3,194			10/12/65	02/13/66	2898 (BC & Kes combined)		19,291,000	6-CN-1
1965	FCS	Keswick	11/15/65	02/23/66	2,966			10/12/65	02/13/66				
1965	FCS	Nimbus										1,086,000	6-CAL-2
1966	WCS	Keswick	06/03/66	06/30/66				06/20/66		2		8,000	6-CN-6
1966	FCS	BC Dam & Ponds	10/03/66	03/31/67	3,995			10/31/66	03/31/67	1900 (BC & Kes combined)		12,696,200	7-CN-9
1966	FCS	Keswick	11/01/66	03/31/67				10/31/66	03/31/67				
1967	WCS	Keswick	05/29/67	06/16/67				06/06/67	06/16/67	7		17,500	7-CN-13
1967	FCS	BC Dam & Ponds	10/13/67	03/25/68	7,440			10/16/67	03/25/68	3,094	2,151	18,400,200	8-CN-1[illegible]
1967	FCS	Keswick	11/08/67	03/25/68				10/16/67	03/25/68				
1968	FCS	BC Dam & Ponds	10/01/68	03/21/69	7,167					2,077	1,465	11,479,497	9-CN-20
1968	FCS	Keswick	11/15/68	03/21/69									
1968	FCS	A.C.I.D. Trap	10/09/68	11/13/68									
1968	FCS	Nimbus										5,643,641	9-UC-23
1969	FCS	BC Dam & Ponds			2,726			10/10/69	01/10/70	2,951	1,831	16,716,328	9-CN-26
1969	FCS	Keswick	11/19/69		4,112				03/20/70				
1970	FCS	BC Dam & Ponds			3,466			10/16/70	03/22/71	3,335	1,782	20,314,565	0-CN-31
1970	FCS	Keswick	10/29/70		4,053				03/22/71				
1971	FCS	BC Dam & Ponds			2,112			10/22/71	03/08/72	1,811	918	11,858,896	1-CN-37
1971	FCS	Keswick			2,186								
1971	FCS	Nimbus										11,145,920	1-UCA-38
1972	FCS	BC Dam & Ponds	09/20/72		3,225		1,461	10/06/72	01/05/73	913	721	5,729,245	2-CM-43
1972	FCS	Nimbus										2,496,760	2-UCA-44
1973	LFS	Keswick			403			11/09/72	01/10/73				
1973	FCS	BC Dam & Ponds			3,502		639	10/12/73	12/12/73	1,547	1,139	8,690,174	3-CM-50
1974	LFS	Keswick	01/14/74	03/14/74	706		57	01/24/74	03/15/74	310	248	2,149,257	3-CM-56
1974	FCS	Nimbus										6,556,[illegible]60	3-UCA-51
1974	FCS	Feather River										4,138,280	3-UCA-52
1974	FCS	BC Dam & Ponds	10/01/74		1,607		353	10/18/74	12/06/74	1,086	636	6,389,597	4-CM-56
1975	LFS	Keswick	11/15/74	02/28/75	2,068		78	12/10/74	03/07/75	636	527	4,113,022	4-CM-57
1975	FCS	Nimbus										3,418,765	4-UCA-58
1975	FCS	BC Dam & Ponds	10/01/75	12/05/75	2,711		696	10/10/75	12/05/75	1,122	746	7,036,664	5-CM-63
1976	LFS	Keswick	11/10/75		911		29	12/02/75	01/16/76	200	229	1,277,175	5-CM-65
1976	FCS	Nimbus										8,246,725	5-UCA-64

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Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1976	FCS	Sacramento River @ RBDD			5,600		623	09/24/76	12/03/76	1,491	890	9,608,235	6-CM-72
1976	FCS	Nimbus										2,426,000	6-UCA-73
1977	LFS	Keswick	09/21/76		756			12/10/76	02/11/77	273	20	1,610,277	6-CM-74
1977	FCS	Sacramento River @ RBDD			4,825		492	09/27/77	12/02/77	1,976	866	12,670,069	7-CM-78
1977	FCS	Feather River										1,553,466	7-UCA-79
1977	FCS	Nimbus										1,589,594	7-UCA-83
1977	FCS	Nimbus										1,575,000	7-UCA-84
1977	SCS	Keswick											
1978	LFS	Keswick			1,853		110	12/06/77	01/07/78	470	536	2,854,249	7-CM-82
1978	WCS	Keswick			63			05/02/78	06/23/78	29	34	121,125	8-CM-86
1978	FCS	BC Dam & Ponds			1,872		830	10/13/78	12/01/78	452	374	2,121,881	8-CM-87
1978	FCS	Mad River Fish Hatchery										815,870	8-UCA-88
1978	SCS	Keswick										none	
1978	FCS	Nimbus										3,676,430	
1979	LFS	Keswick			829		21	12/06/77	02/09/78	325	335	1,738,304	8-CM-90
1979	FCS	BC Dam & Ponds			8,729		3,894	10/02/79	11/30/79	2,669	1,747	15,639,290	9-CM-91 & 9-CM-94
1980	LFS	Keswick			867		38	12/10/79	02/29/80	373	276	1,939,000	9-CM-93
1980	FCS	BC Dam & Ponds			7,628		572	10/10/80	11/28/80	3,580	2,918	17,804,000	0-CM-96
1981	LFS	Keswick			2,065		190	12/01/80	02/11/81	814	684	3,614,000	0-CM-97
1981	FCS	BC Dam & Ponds			10,173		7,323	10/02/81	11/30/81	2,233	1,035	11,515,000	1-CM-99
1981	FCS	Keswick			1,300								
1982	LFS	Keswick			1,866		218	12/03/81	02/18/82	553	567	2,765,000	2-CM-02
1982	LFS	BC Dam & Ponds			141								
1982	WCS	Keswick			57			05/11/82	05/25/82	7 (5)	11	35,000	2-CM-03
1982	FCS	BC Dam & Ponds			19,361		3,276	10/04/82	11/29/82	5,519	5,264	26,624,000	2-CM-04
1982	FCS	Keswick			93								
1983	LFS	BC Dam & Ponds			183		31	12/02/82	03/11/83	356	342	1,858,000	2-CM-06
1983	LFS	RBDD			343			12/02/82	03/11/83				
1983	LFS	Keswick			432			12/02/82	03/11/83				
1983	FCS	Keswick			212		3,401	10/03/83	12/05/83	2,725	1,295	9,845,886	3-CM-08
1983	FCS	BC Dam & Ponds			8754								
1983	FCS	Feather River										900,000	3-UCA-09
1984	LFS	BC Dam & Ponds			51		289	12/14/83	03/15/84	177	94	669,901	3-CM-12
1984	LFS	RBDD			153								
1984	LFS	Keswick			424								
1984	WCS	Keswick & RBDD			34					0	0		
1984	FCS	BC Dam & Ponds			21,543		2,916	10/01/84	12/12/84	7,841	8,723	27,814,636	4-CM-13
1985	LFS	BC Dam & Ponds			23		42	12/19/84	02/26/85	141	142	597,378	5-CM-15
1985	LFS	Keswick			365			12/19/84	02/26/85				

Appendix 6A. Summary of chinook salmon spawning at Coleman and Livingston Stone National Fish Hatcheries including brood year, run (race), collection location, capture and spawning dates, number of males, females, and jacks collected and spawned, number of eggs collected, and lot number. Information in this table may be cross-tabulated with distribution data (Appendix 10A) using "lot number" as an index field.

Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1985	WCS	Keswick & RBDD					0			32	0		
1985	FCS	BC Dam & Ponds			26,205		4,561	10/01/85	12/10/85	4,495	5,641	24,700,000	5-CM-16
1985	FCS	Keswick			636			10/01/85	12/10/85				
1986	LFS	BC Dam & Ponds			364		29	12/17/85	02/13/86	216	208	1,060,000	6-CM-18
1986	LFS	Keswick			376			12/17/85	02/13/86				
1986	FCS	BC Dam & Ponds			19,744		1,221	10/06/86	12/11/86	5,421	5,360	23,818,300	6-CM-19
1986	FCS	Keswick			228			10/06/86	12/11/86				
1987	LFS	BC Dam & Ponds			349		13	12/18/86	02/19/87	341	287	1,941,227	7-CM-22
1987	LFS	Keswick			454			12/18/86	02/19/87				7-CM-21
1987	FCS	BC Dam & Ponds			18,446		6,269	10/04/87	12/16/87	4,952	3,706	25,661,469	
1988	LFS	BC Dam & Ponds			53		38	12/23/87	03/15/88	186	169	1,051,500	8-CM-26
1988	LFS	Keswick			411			12/23/87	03/15/88				8-CM-25
1988	WCS												
1988	FCS	BC Dam & Ponds			15,552	6,683	1,175	10/06/88	12/14/88	5,139	6,585	25,884,382	8-CM-27
1989	LFS	Keswick			817	392	2	01/04/89	04/06/89	318	318	1,761,218	9-CM-30
1989	LFS	BC Dam & Ponds			65	29	12	12/21/88	04/06/89	22	20	96,591	9-CM-29
1989	WCS	RBDD & Keswick	03/15/89	05/02/89	42	22	0	06/29/89	06/29/89	1	1	6,191	9-CM-32
1989	FCS	BC Dam & Ponds			11,986		1,607	10/05/89	12/18/89	3,237	5,343	18,096,155	FCS-BCW-89-COL
1990	LFS	BC Dam & Ponds			92	41	11	01/03/90	02/12/90	31	30	138,067	LFS-BCW-90-COL
1990	LFS	Keswick			100	35	2	01/03/90	03/27/90	22	43	112,208	LFS-KEW-90-COL
1990	WCS	Keswick	01/22/90	05/01/90	14	10	0	05/09/90	05/09/90	1	1	5,012	WCS-SRW-90-COL
1990	FCS	BC Dam & Ponds			14,650	6,406	1,150	10/03/90	12/27/90	5,411	5,502	28,609,707	FCS-BCW-90-COL
1991	LFS	BC Dam & Ponds			161	65	15	01/04/91	02/19/91	60	65	217,344	LFS-BCW-91-COL
1991	LFS	Keswick			118	49	4	01/04/91	02/19/91	45	53	235,497	LFS-KEW-91-COL
1991	WCS	RBDD & Keswick	03/29/91	06/05/91	23	10	8	04/16/91	06/17/92	6	13	29,919	WCS-SRW-91-COL
1991	FCS	BC Dam & Ponds			10,689	5,834	613	10/10/91	12/13/91	4,692	3,709	25,187,384	FCS-BCW-91-COL
1992	LFS	BC Dam & Ponds			344	164	9	12/27/91	02/24/92	119	95	534,365	LFS-BCW-92-COL
1992	LFS	Keswick			399	239	3	12/18/91	02/18/92	161	77	783,756	LFS-KEW-92-COL
1992	LFS	BC & Keswick			21							57,659	LFS-BxK-92-COL
1992	WCS	Keswick	04/10/92	06/04/92	29	14		05/05/92	07/01/92	13	13	59,445	WCS-SRW-92-COL
1992	FCS	BC Dam & Ponds			7,275	2,970	1,039	10/13/92	12/17/92	2,693	2,674	14,134,423	FCS-BCW-92-COL
1993	LFS	BC Dam & Ponds			526	187	172	12/30/92	03/02/93	130	159	536,408	LFS-BCW-93
1993	LFS	Keswick			375	166	7	12/30/92	03/02/93	124	131	739,935	LFS-KEW-93
1993	WCS	RBDD & Keswick	04/23/93	06/04/93	18	12	2	04/30/93	07/27/93	11	3	47,157	WCS-SRW-93-COL
1993	FCS	BC Dam & Ponds			7,587	3,753	565	10/06/93	12/07/93	3,487	2,770	17,979,774	FCS-BCW-93-COL
1994	LFS	BC Dam & Ponds			598	197	169	12/28/93	03/01/94	151	145	527,914	LFS-BCW-94-COL

Appendix 6A. Summary of chinook salmon spawning at Coleman and Livingston Stone National Fish Hatcheries including brood year, run (race), collection location, capture and spawning dates, number of males, females, and jacks collected and spawned, number of eggs collected, and lot number. Information in this table may be cross-tabulated with distribution data (Appendix 10A) using "lot number" as an index field.

Brood Year	Species / Run	Adult Collection Location	Beg. Capture Date	End Capture Date	Total Fish Handled	Total Females	Total Jacks	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot Number
1994	LFS	KES	12/13/93		154	80	4	12/28/93	02/15/94	62	48	300,423	LFS-KEW-94-COL
1994	WCS		02/10/94	04/22/94	29	18		05/24/94	07/05/94	16	11	61,614	WCS-SRW-94-COL
1994	FCS	BC			18,991	4,308	7,443	10/06/94	11/22/94	3,771	4,728	19,595,404	FCS-BCW-94-COL
1995	LFS	BC			492	222	45	12/28/94	02/07/95	182	130	730,558	LFS-BCW-95-COL
1995	LFS	Keswick			224	115	10	12/28/94	03/01/95	97	67	527,800	LFS-KEW-95-COL
1995	WCS	Keswick	03/01/95	06/27/95	85			06/20/95	07/24/95	21	16	83,005	WCS-SRW-95-COL
1995	FCS	BC			26,677	11,138	1,883	10/10/95	11/27/95	3,882	4,277	21,311,599	FCS-BCW-95-COL
1996	LFS	BC			1,337	541	374	12/28/95	02/27/96	231	164	1,082,716	LFS-BCW-96-COL
1996	LFS	Keswick			48	29	1	01/16/96	02/05/96	25	16	154,757	LFS-KEW-96-COL
1996	FCS	BC			21,178	8,888	2,355	10/09/96	11/19/96	4,264	4,713	24,556,946	FCS-BCW-96-COL
1997	LFS	BC			4,578	1,996	451	12/26/96	02/19/97	368	414	1,615,277	LFS-BCW-97-COL
1997	WCS	Captive Broodstock	NA	NA				07/31/97	08/13/97	107	68	181,834	WCS-CAP-97-BML
1997	FCS	BC			50,670	24,467	6,032	10/07/97	11/19/97	4,104	4,840	23,996,644	FCS-BCW-97-COL
1998	LFS	BC			3,069	1,328	492	12/30/97	02/24/98	403	359	1,845,361	LFS-BCW-98-COL
1998	WCS	Keswick	04/08/98	05/21/98				05/01/98	07/02/98			205,668	WCS-SRW-98-LIV
1998	FCS	BC			44,121	19,075	1,804	10/07/97	11/19/97	3,136	4,440	15,680,000	FCS-BCW-98-COL
1999	LFS	BC	12/09/98	03/02/99	7,075	2,528	709	12/29/98	03/02/99	422	542	1,366,069	LFS-BCW-99-COL
1999	WCS	Keswick and RBDD	04/14/99	06/17/99	41			05/01/99	07/08/99	9	14		WCS-SRW-99-LIV
1999	WCS	Captive Broodstock	NA	NA									WCS-CAP-99-BML

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Appendix 6B. Summary of steelhead and rainbow trout spawning at Coleman National Fish Hatchery including: brood year, stock, stock source, capture and spawning dates, total number of fish handled, numbers of females and males spawned, number of eggs collected, and lot number. Historic data presented were reconstructed from hatchery records that are incomplete and may not be accurate.This table may be cross-tabulated with distribution data (Appendix 10B) using "lot number" as an index field.

Brood Year	Stock	Source	Date Rec'd	Beg. Capture Date	End Capture Date	Total Fish Handled	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot No.
1947	Steelhead	Keswick		02/20/47	02/26/47				19		31,250	16
1949	Steelhead	Station Broodstock		12/16/48	03/14/49				9		147,133	20
1950	Steelhead	Station Broodstock		11/25/49	03/03/50				126		268,385	24
1950	Kamloops	British Columbia, CAN	06/29/49								2,119	21
1951	Steelhead	Station Broodstock		10/26/50					79		159,936	29
1951	Kamloops	British Columbia, CAN	07/26/50								100,000	26
1951	Rainbow Trout	Pocatello, ID	02/06/50								230,395	25
1951	Kamloops	British Columbia, CAN	07/22/51								150,000	31
1952	Steelhead	Battle Creek		01/28/52	03/10/52				78		167,964	35
1953	Steelhead	Battle Creek		12/17/52	03/25/53		01/01/53	03/25/53	121		259,711	40
1953	Kamloops	British Columbia, CAN	07/13/52								283,995	37
1953	Kamloops	Greenough, MT	02/13/52								39,005	36
1954	Steelhead	Battle Creek		12/09/53	03/15/54	381	12/16/53	03/15/54	158	106	379,563	44
1954	Kamloops	Missoula, MT	02/23/53								176,045	41 & 42
1955	Steelhead	Battle Creek			05/04/55	960	01/03/55	03/12/55	156	88	465,970	5CM
1956	Steelhead	Battle Creek and Keswick		09/14/55	03/30/56	920	01/03/56	03/30/56	169	69	501,342	6CM
1956	Rainbow Trout	Hagerman, ID	08/15/55								23,600	5H
1957	Steelhead	Battle Creek and Keswick		09/21/56	03/29/57	889	01/02/57	02/28/57	286	45	600,000	7-CM-54
1957	Rainbow Trout	Hagerman, ID									50,880	6H
1957	Kamloops	Station Broodstock		09/21/56	03/29/57		01/02/57	02/28/57				7CM
1957	Kamloops	Fort Klamath, OR									209,875	7-ORE-55
1958	Steelhead	Battle Creek and Keswick		09/30/57	04/28/58	1,527	01/08/58	02/20/58	258	82	708,249	8-CM-59
1958	Kamloops	Coleman, CA									47,625	8-CM-65
1958	Kamloops	Diamond Lake, ORE									100,000	8-ORE-61
1958	Rainbow Trout	Mount Shasta, CA									50,800	8-CAL-58
1959	Steelhead	Battle Creek and Keswick		09/16/58	03/30/59		01/15/59	03/30/59	287	137	827,127	9-CM-66
1960	Steelhead	Battle Creek and Keswick		09/28/59	04/15/60		01/29/60	04/15/60	357	207	791,000	0-CM-71
1960	Kamloops	Diamond Lk., OR									102,285	9-ORE-67
1960	Kamloops	Coleman, CA									45,526	9-CM-70
1960	Kamloops	Coleman, CA									110800	0-CM-76
1960	Kamloops	Diamond Lake, OR					06/24/60				102,900	0-ORE-72
1961	Steelhead	Battle Creek and Keswick	08/13/60	09/13/60	02/24/61		01/09/61	02/24/61	545	195	1,583,000	1-CN-77
1962	Steelhead	Battle Creek and Keswick		09/26/61	02/24/62		01/09/62	03/28/62	699	256	1,810,000	2-CN-81
1962	Kamloops	Colman, CA		12/14/60							110,000	1-CN-76

Appendix 6B. Summary of steelhead and rainbow trout spawning at Coleman National Fish Hatchery including: brood year, stock, stock source, capture and spawning dates, total number of fish handled, numbers of females and males spawned, number of eggs collected, and lot number. Historic data presented were reconstructed from hatchery records that are incomplete and may not be accurate. This table may be cross-tabulated with distribution data (Appendix 10B) using "lot number" as an index field.

Brood Year	Stock	Source	Date Rec'd	Beg. Capture Date	End Capture Date	Total Fish Handled	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot No.
1962	Kamloops	Coleman, CA		12/19/61							213,000	2-CN-60
1963	Steelhead	Battle Creek and Keswick		10/01/62							2,000,000	3-CN-86
1963	Kamloops	Coleman, CA		12/07/62							185,000	3-CN-84
1964	Steelhead	Battle Creek and Keswick		10/03/63	04/14/64	1,594	01/07/64	04/24/64	732	303	2,250,000	4-CN-91
1964	Kamloops	Coleman, CA					12/05/63				372,000	4-CN-90
1965	Steelhead	Battle Creek and Keswick		10/01/64	03/22/65	2920			1,481	890	3,713,000	5-CN-96
1966	Steelhead	Spillway		10/05/65	03/07/66		01/05/66	03/21/66			1,900	6-CN-8
1966	Kamloops	Battle Creek		10/01/64	03/22/65						600,000	5-CN-95
1966	Steelhead	Battle Creek		10/05/65	03/07/66	1,843			737		2,581,000	6-CN-4
1966	Kamloops	Coleman, CA									781,000	6-CN-3
1966	Rainbow Trout	Winthrop NFH									35,480	6-WP-5
1967	Steelhead	Battle Creek					01/05/67	03/07/67	854	483	2,706,087	7-CN-11
1967	Kamloops	Station Broodstock							381	150	968,000	7-CN-10
1967	Rainbow Trout	Ennis, MT									75,100	7-E-12
1968	Steelhead	Battle Creek									3,000,000	8-CN-18
1968	Kamloops										3,374	6-CN-7
1968	Kamloops										1,148,000	8-CM-16
1968	Rainbow Trout	Ennis, MT									3,003	7-DS-14
1968	Rainbow Trout	Ennis, MT									206,500	8-E-19
1969	Steelhead	Battle Creek		10/01/68	03/21/69	4,939	12/19/68	02/07/69	647	335	2,596,242	9-CN-22
1969	Kamloops	Station Broodstock							615	493	1,685,200	9-CN-21
1969	Rainbow Trout	Winthrop NFH									200,300	9-WP-24
1969	Rainbow Trout	MT. Whitney SFH (CDFG)									100,500	9-UC-25
1970	Steelhead	Battle Creek and Keswick		10/10/69		3,967			758	204	2,810,526	9-CN-28
1970	Kamloops	Station Broodstock							720		1,007,804	O-CN-27
1970	Rainbow Trout										30,258	O-E-29
1970	Rainbow Trout										175,400	O-UC-30
1971	Steelhead	Battle Creek and Keswick		10/01/70		3,529			900		3,309,877	0-CN-32
1972	Kamloops	Station Broodstock							835	734	1,967,832	1-CN-33
1972	Kamloops	Clark Fork Hatchery, ID									46,200	1-UID-34
1972	Rainbow Trout	Calif Dept of Fish and Game									96,975	0-UC-35
1972	Rainbow Trout	Calif Dept of Fish and Game									1,037,604	1-UC-36
1972	Steelhead	Battle Creek and Keswick				1,377	12/22/71		393	350	1,282,437	1-CM-40
1972	Steelhead	Nimbus Hatchery									1,039,363	1-UCA-41

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Appendix 6B. Summary of steelhead and rainbow trout spawning at Coleman National Fish Hatchery including: brood year, stock, stock source, capture and spawning dates, total number of fish handled, numbers of females and males spawned, number of eggs collected, and lot number. Historic data presented were reconstructed from hatchery records that are incomplete and may not be accurate.This table may be cross-tabulated with distribution data (Appendix 10B) using "lot number" as an index field.

Brood Year	Stock	Source	Date Rec'd	Beg. Capture Date	End Capture Date	Total Fish Handled	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot No.
1972	Rainbow Trout	Ennis, MT									1,297,746	2-EN-39
1973	Steelhead	Battle Creek		09/20/72	01/05/73	2,645			1,007	900	3,131,355	2-CM-45
1973	Kamloops	Hot Creek SFH, CDFG									231,000	3-UCA-46
1973	Kamloops	Station Broodstock									1,112,005	3-UID-47
1973	Rainbow Trout	Mount Shasta Hatchery, CA									309,474	3-UCA-48
1974	Steelhead	Battle Creek and Keswick				1,746	12/19/73		655	218	2,129,239	3-CM-54
1974	Kamloops	Station Broodstock							808	1,291	2,283,505	4-UID-53
1975	Steelhead	Battle Creek		10/01/74			12/17/74	02/12/75	431	301	1,840,077	4-CM-59
1975	Steelhead	Nimbus Hatchery							63		423,879	4-UCA-60
1975	Kamloops	Station Broodstock									2,554,546	5-UID-61
1975	Kamloops	Darrah Springs									9,924	Darrah Sp
1976	Steelhead	Battle Creek		10/01/75			12/16/75	02/19/76	588	636	2,356,868	5-CM-66
1976	Steelhead	Nimbus Hatchery, CA									99,990	5-UCA-67
1976	Kamloops	Station Broodstock							475		1,324,588	6-UID-68
1976	Kamloops	Station Broodstock									5,021	5-UID-61
1976	Kamloops	Station Broodstock									376,700	6-CM-69
1976	Kamloops	Nimbus SFH ?									>33488	6-UCA-71
1977	Steelhead	Battle Creek and Keswick					12/20/76	03/01/77	630		2,187,500	6-CM-75
1977	Steelhead	Nimbus Hatchery, CA									219,240	6-UCA-76
1977	Kamloops	Clark Fork Hatchery, ID							846		2,169,095	7-UID-77
1978	Steelhead	Sacramento River @ RBDD									623,000	7-CM-80
1978	Steelhead	Mad River									1,456,000	7-UCA-85
1978	Kamloops	Hot Creek Hatchery, CA									795,000	8-UCA-81
1979	Steelhead	Battle Creek									955,541	8-CM-89
1980	Steelhead	Battle Creek							751		3,229,115	9-CM-92
1980	Steelhead	Eel River Strain returns to B.C.							23		95,616	9-CM-92
1981	Steelhead	Battle Creek							324		1,000,000	0-CM-98
1982	Steelhead	Battle Creek				1,250	12/15/81	02/23/82	525		1,575,000	2-CM-01
1983	Steelhead	Battle Creek and Keswick				870	12/08/82	02/16/83	380	183	1,398,000	2-CM-05
1983	Steelhead	Feather River Hatchery									500,000	2-UCA-07
1984	Steelhead	Battle Creek and Keswick				521	12/21/83	02/22/84	295	232	459,672	3-CM-10
1984	Steelhead	Nimubs Hatchery, CA									700,000	3-UCA-11
1985	Steelhead	Battle Creek and Keswick				2,020	12/11/84	02/26/85	715	363	2,723,830	5-CM-14
1986	Steelhead	Battle Creek and Keswick				2,042	12/13/85	01/30/86	909		2,983,600	6-CM-17

Appendix 6B. **Summary of steelhead and rainbow trout spawning at Coleman National Fish Hatchery including: brood year, stock, stock source, capture and spawning dates, total number of fish handled, numbers of females and males spawned, number of eggs collected, and lot number. Historic data presented were reconstructed from hatchery records that are incomplete and may not be accurate.This table may be cross-tabulated with distribution data (Appendix 10B) using "lot number" as an index field.**

Brood Year	Stock	Source	Date Rec'd	Beg. Capture Date	End Capture Date	Total Fish Handled	Beg Spawn Date	End Spawn Date	Spawned Females	Spawned Males	Total Eggs	Lot No.
1987	Steelhead	Battle Creek				1,194	12/17/86	03/11/87	260	248	1,092,000	7-CM-20
1988	Steelhead	Battle Creek				890	12/17/87	03/01/88	222	174	958,628	8-CM-24
1989	Steelhead	Battle Creek				487	12/21/88	02/09/89	27	18	118,913	9-CM-28
1989	Steelhead	Feather River SFH, CDFG									47,000	STT-SBW-89-COL
1990	Steelhead	Battle Creek		10/04/89	02/12/90	4,172	12/11/89	02/12/90	629	463	2,574,104	STT-SBW-90-COL
1991	Steelhead	Battle Creek		10/02/90	02/19/91	1,143	12/12/90	02/19/91	394	436	1,732,341	STT-SBW-91-COL
1992	Steelhead	Battle Creek		10/09/91	03/03/92	4,429	12/19/91	02/24/92	323	205	1,343,039	STT-SBW-92
1993	Steelhead	Battle Creek		10/12/92	03/02/93	2,862	12/29/92	03/02/93	343	332	1,519,175	STT-SBW-93-COL
1994	Steelhead	Battle Creek		10/07/93	03/08/94	3,387	12/16/93	03/01/94	363	322	1,683,853	STT-SBW-94-COL
1995	Steelhead	Battle Creek		10/05/94	02/15/95	2,185	12/27/94	01/12/95	311	279	1,493,013	STT-SBW-95-COL
1996	Steelhead	Battle Creek		10/09/95	02/27/96	3,106	12/21/95	01/30/96	231	215	1,167,484	STT-SBW-96-COL
1997	Steelhead	Battle Creek		10/08/96	03/03/97	2,529	12/20/96	02/12/97	181	186	885,046	STT-SBW-97-COL
1998	Steelhead	Battle Creek		10/06/97	03/02/98	1,409	12/17/97	02/10/98	193	187	940,045	STT-SBW-98-COL
1999	Steelhead	Battle Creek		10/06/98	03/02/99	1,755	01/14/99	03/02/99	164	165	739,306	STT-SBW-99-COL
2000	Steelhead	Battle Creek		10/05/99	03/02/00	1,976	01/03/00	02/15/00	183	187		STT-SBW-00-COL

Appendix 6C. Genetic selection of winter chinook salmon broodstock

The following information on genetic selection of winter chinook broodstock is excerpted from the Service's 1998 ESA Section 10 permit supplements justifying a re-initiation of the winter chinook salmon propagation program.

A genetic run discrimination project supported with funding from the California Department of Water Resources was awarded to Dr. Dennis Hedgecock of Bodega Marine Laboratory (BML) in May 1994. This project was designed to identify genetic markers (microsatellites) through non-lethal tissue sampling allowing the discrimination of winter chinook from fall, late-fall and spring chinook salmon. By 1995 three polymorphic DNA markers had been characterized by the BML genetics laboratory, including the powerful locus Ots-2 which is particularly discriminating for winter chinook salmon (Banks et al. 1996).

These technologies were applied to tissues collected from the spawned and unspawned groups of chinook salmon collected during the 1995 winter chinook salmon trapping operations. Results of this analysis indicated potential hybridization between brood year 1995 winter chinook salmon adults and other runs of chinook salmon (spring run) in the winter chinook propagation program at Coleman NFH (Hedgecock et al. 1995). The genotypic proportions in the spawned group departed significantly from random-mating expectations and in a manner suggesting admixture (Hedgecock et al. 1995; Arkush et al. 1997). Although individual salmon identified as non-winter run had the phenotypic spawn timing criteria (mid-April through mid-August) and run-timing criteria previously accepted for winter chinook salmon, genetic analysis suggested a number of individuals spawned in 1995 were not winter chinook salmon. The individual adults (five males) most likely responsible for Hardy-Weinberg equilibrium failure were identified by BML and, as a precautionary measure, all juveniles resulting from those matings were destroyed (approximately 1300). Subsequent analysis of previous brood years (1993 and 1994) also resulted in the conclusion that hybridization may have occurred in those brood years as well (two females in 1993 and one female in 1994). These findings of potential hybridization within the hatchery population, together with an imprinting problem causing hatchery fish to return to Battle Creek instead of the Sacramento River, led to a moratorium on the future capture of adult salmon for this program. The moratorium was expected to remain in effect until a genetic testing protocol was developed that would reduce potential risk of hybridization attributable to the artificial propagation program.

Verification of the genetic discrimination tool

False Positive Results

By 1997, opportunities to evaluate the ability of the genetic tool to discriminate winter chinook salmon from other runs of salmon became available. Continuing work at the BML genetics laboratory resulted in the development of two new diagnostic microsatellite markers (five total), and substantially increased the number of fish used in the baseline data set. The discriminating power of the five microsatellite markers was evaluated on two separate occasions in 1997 and 1998. The first test characterized to run a blind submission of tissue samples (i.e., tissue samples only, all other information withheld from the researcher) sent to BML from the CDFG's Rancho Cordova tissue archive. The second test characterized to run a set of tissues obtained from a trapping and relocation effort for winter chinook salmon returning to Battle Creek from March-May 1997. The results from both the genetic tests and the accuracy of identifying winter and non-winter chinook salmon, suggested the genetic tool performed adequately. The genetic discrimination methodology demonstrated 100% accuracy in its ability for selection against other runs (i.e., no "false positives," or non-winter chinook salmon identified as winters). Additionally, the test involving submission of tissues from CDFG's tissue archive demonstrated reproducibility of the methods used for genetic identification.

More robust testing of the potential for false positive results generated through use of the genetic discrimination tool was accomplished through computer simulations and modeling, which would involve randomly drawing a sample from the available baselines, and determining the accuracy of the resultant genetic call. Preliminary modeling (jackknife allocations) of this nature has been conducted (M. Banks, pers. comm., January 1998), on the same baselines used during the Battle Creek trapping operation. During this simulation, analysis of approximately 782 fish resulted in one "false positive," an error rate of 0.0013. Therefore, data generated through actual tissue submissions and computer simulations suggest the current probability of selecting a non-winter-run chinook salmon for inclusion in the hatchery program is less than 0.2%.

False Negative Results

The Battle Creek trapping operation allowed an estimate to be made of the occurrence of "false negatives" (i.e., failing to select an actual winter chinook salmon for the program). For this analysis, the ability to identify suspect hybrid fish are included to test the genetic tools ability to identify a winter chinook (suspect hybrid or not). The discrimination of suspected hybrid salmon as winter chinook salmon may be more difficult due to their genomic make-up, the generated data can be used to describe worst-case scenarios, which are more appropriate in conducting a risk analysis. Three of the 14 known winter chinook salmon or suspect hybrid groups (lineage information based on CWT recoveries) captured and sacrificed during Battle Creek trapping efforts during 1997 and 1998 were identified as non-winter chinook salmon. Additionally, one of the 68 relocated fish from Battle Creek was subsequently recovered during the Sacramento River carcass survey, and CWT extraction confirmed this as a brood year 1994 winter chinook salmon. Therefore, the total sample size in determining the rejection rate ("false negatives") of actual winter chinook salmon is 82 (14 sacrificed + 68 relocated). With three of those individuals called non-winter chinook, an estimate of "false negatives" would be approximately 5% (3/82 = 3.7%). Two salmon which were sacrificed but resulted in no CWT recovery might also be considered in this analysis as the first genetic call also identified these two as fall chinook, with the second call being winter. These two additional salmon fit the pattern of the three salmon called fall chinook but verified as winter chinook through CWT recovery. Because CWT recovery on these two additional fish was not possible, they could be considered to be misidentified, thereby increasing the estimate of "false negatives" to 6.1%. For the purpose of this risk analysis, the 6.1% rate of misidentification will be noted as a worst case scenario. False negatives will not likely harm the genetic integrity of the stock as they will be released to spawn in the wild.

The probability of rejecting an actual winter chinook salmon from the program based on genetic analysis was presented in the February 20, 1998 Section 10 Permit Supplement as approximately 6.1%. That value was based on evaluation of the results of genetic analysis against known coded-wire tagged samples or other samples of known origin. The genetic selection criteria adopted by the Winter Chinook Salmon Captive Broodstock Committee, however, used a LOD score ≥ 2[1]. This selection criterion coincides with a 99% confidence that a particular call is actually a winter chinook salmon. This high confidence for selection of winter chinook salmon may increase the probability of rejecting actual winter chinook salmon from the program above the 6.1% presented in the Permit Supplement. Jackknife allocations using a LOD of ≥2 were conducted by BML. These allocations resulted in a rejection rate for winter chinook salmon (false negatives) of approximately 8%. The genetic risk associated with this rate of rejection of actual winter chinook salmon from the program was also deemed acceptable by the group, and refinement of the baselines lead to the refinement of both false positives and false negatives

Use of the genetic discrimination tool in conjunction with phenotypic selection criteria (capture timing and spawning timing) would further reduce the risk for the incorporation of a non-winter chinook salmon into the program (false positive). Using the combination of phenotypic and genetic selection criteria, the probability of selecting an individual non-winter chinook salmon for the program has been estimated at only 0.01%. A decision making tree which describes the risk probabilities at each step is shown below. The decision making tree uses information from three steps to estimate the risk of collecting and incorporating a non-winter chinook salmon into the propagation program.

> ***Step 1–Meets Phenotypic Capture Criteria***: Winter chinook salmon are expected to be arriving in the upper Sacramento River from December through August. Therefore, the first criterion is that an individual is captured during this time period (March-August in collection year 1998). During the capture window, data from 1995 were used to represent the worst case scenario in which approximately 50% of the individuals (although captured during the right time period), did not spawn during the spawning window (May 1-Aug 1). Therefore, based on phenotypic spawn timing, these fish would not be considered winter chinook even though they were captured during the winter collection period. So worst case is **50%** of the fish collected during the collection window could be non-winter chinook salmon.

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[1] LOD score is the log base 10 of the ratio of the likelihood functions of the two runs from which a particular fish is most likely to belong, and have been even further improved to incorporate MSA information (Dennis Hedgecock, email transmission, March 2000). Likelihood functions are generated based on allele frequency distributions at multiple loci. See the 20 February 1998 Permit Supplement for further description of this value.

Step 2--Meets Genetic Criteria: An LOD score ≥ 2 must be achieved for a particular salmon to be retained in the program. Preliminary modeling (jackknife allocations) suggests the likelihood of a non-winter chinook salmon being retained for the program following genetic analysis is approximately 0.1% (M. Banks, pers. comm.). During the simulation, analysis of approximately 782 fish resulted in one "false positive," an error rate of 0.0013. Therefore, data generated through actual tissue submissions and computer simulations suggest that the probability of a non-winter chinook salmon being retained for the program following genetic analysis is approximately 0.2%.

Step 3--Meets Phenotypic Spawn Timing: Although the spawning window for winter chinook is generally considered to be mid-April through mid- August, the Service has condensed this spawning window for this program to reduce the potential for mating winter chinook salmon with other runs (see USFWS 1993). Currently, winter chinook used in the artificial propagation program must spawn between May 1 and August 1. Fish captured for the program that meet the genetic selection criteria must then meet the spawn timing criterion. This means that of the 50% non-winter chinook collected in Step 1, 0.2% might be retained for the program through Step 2 (50% x 0.2% = 0.1%). Although 100% or 0% of those non-winters retained could be spawned in the program, data again from 1995 suggest that of approximately 43 non-winter (genetically or phenotypically), five were spawned within the spawning window criteria (12%). These data allow an estimate (12%) to be generated for the probability of a non-winter chinook salmon "passing" criteria for the first two steps, and meeting the final spawn timing criterion resulting in the contribution of gametes to the program. The final risk analysis would be the product of the three values from above as follows:

50% non-winters captured for the program
X
0.2% of non-winters captured retained for the program after meeting genetic criteria
X
12% of non-winters retained for program meeting spawn timing criterion
= 0.012%

Recent improvements to the genetic discrimination tool
Beginning with brood year 1999, the genetic selection criterion of LOD ≥ 1 using microsatellites has been used to select individuals for inclusion into the hatchery program. This criterion was adopted by the genetic subcommittee of the Winter Chinook Salmon Captive Broodstock Committee as a result of the refinement of genetic marker sets (i.e., including two additional loci, for a total of seven loci). The currently adopted value of LOD ≥ 1 reduces the potential of rejecting actual winter chinook salmon from the program, however, a quantitative assessment of this reduction has not been calculated.

Broodstock collection criteria for the winter chinook propagation program are conservative; some winter chinook salmon may be rejected from the program, while, based on the results of these tests and computer simulations, non-winter chinook salmon will likely not be selected for the program. The results from tests and computer simulations show that genetic analysis is capable of discriminating winter chinook salmon from other upper Sacramento River stocks of chinook salmon. The potential genetic impacts of "false positives" occurring at a rate ~0.1% and "false negatives" occurring at a rate of ~8% has been discussed by the Genetics Subcommittee of the Winter Chinook Salmon Captive Broodstock Committee and is considered sufficient to reduce the potential genetic risks of the artificial propagation program, thus protecting the genetic integrity of the naturally-reproducing population the program is designed to supplement.

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Appendix 6D. Genetic Risks of Hatchery Propagation

Introduction

Genetic effects of artificial propagation to natural salmonid populations is a complex and controversial issue. In the western United States salmon hatcheries are viewed as both a cause for the decline of Pacific salmonids and a tool to assist in recovering populations. Direct genetic effects potentially resulting from hatchery propagation include: 1) genetic effects of artificial propagation on hatchery fish, and 2) genetic effects resulting from hatchery and natural fish interbreeding (Campton 1995). Additional indirect genetic effects can result from ecological interactions between hatchery and natural fish (e.g., competition, predation, disease transfer) or from management decisions (e.g., mixed-stock fishing mortality)(Campton 1995).

The general approach of the Service for managing genetic risks of hatchery propagation programs at Coleman NFH is to maintain genetic similarity with natural stocks and minimize adaptation to the hatchery environment. These objectives are accomplished by propagating locally-adapted populations, implementation of 'genetically-conscious' protocols for hatchery operations (e.g., one-to-one matings, spawning throughout run timing, maintaining large effective population size), and incorporating natural-origin adults as hatchery broodstock. By implementing these strategies, the Service believes genetic risks of hatchery propagation programs at Coleman NFH are minimized.

Potential Genetic Impacts

Several studies have shown genetic differences between hatchery and wild populations of Pacific salmonids resulting from artificial propagation (see review in Campton 1995), and many report decreased fitness of natural populations following hatchery introgression (e.g., Chilcote et al. 1986, Nickelson et al. 1986, Fleming and Gross 1992 and 1993, Currens et al. 1997, Unwin 1997, Unwin and Glova 1997[1]). In many of these studies, however, interpretation of results are confounded because either: 1) phenotypic differences were initially apparent between hatchery and natural populations (e.g., Reisenbichler and McIntyre 1977, Nickelson et al. 1986); 2) hatchery stocks did not originate from local natural populations (e.g., Chilcote et al. 1986, Currens et al. 1997); or, 3) hatchery stocks had been propagated in isolation from natural populations (e.g., Chilcote et al. 1986, Fleming and Gross 1992 and 1993, Unwin 1997, Unwin and Glova 1997). In several of these studies, it is likely that more than one of these factors influenced the results. Regardless, the preponderance of published literature appears to suggest that genetic changes resulting from artificial propagation can reduce genetic fitness of the hatchery stock in the wild, possibly leading to reduced productivity and viability of natural populations. Reisenbichler and Rubin (1999) reported at least three studies which used hatchery and natural stocks from local populations that also concluded that artificial propagation programs resulted in significant genetic change.

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[1] An additional list of available literature on potential genetic impacts follows the literature cited for this section.

Potential detrimental genetic effects from artificial propagation programs include: 1) extinction; 2) loss of within population genetic variability; 3) loss of between population genetic variability; and, 4) domestication (Hindar et al. 1991, Waples 1991, Busack and Currens 1995, Campton 1995, Waples and Allendorf 1995). General descriptions of these risks are presented below.

Extinction. Artificial propagation programs may result in a loss of natural production directly by removing adults from the naturally spawning population. If an artificial propagation program continues to remove adults from the naturally spawning population (sometimes referred to as 'mining' the natural population), the propagation program becomes a population 'sink'. When the propagated species is at an extremely low level of abundance, a population sink could lead to extinction through a direct loss of individuals and their genetic material. However, there is no documented evidence of stock extinctions resulting from artificial propagation programs. To the contrary, artificial propagation has been used to reduce the short-term risk of extinction (e.g., the Service's winter chinook program)- the success of this is still unknown.

Loss of within-population variation. Small population sizes in a hatchery breeding program can lead to losses of within-population genetic variability through inbreeding depression and genetic drift (Waples 1991b). Both of these genetic concerns are increased when dealing with small or declining populations. Decreased within-population genetic variation resulting from inbreeding depression may cause reductions in viability, survival, growth, or egg production, and increased rate of abnormalities (Cuenco et al. 1993). Genetic drift can also result in the loss of rare alleles. Both inbreeding depression and genetic drift could reduce the fitness of the hatchery stock in the wild by decreasing the potential for adaptation to local environments.

Loss of between-population variation. Artificial propagation programs may decrease between-population genetic variability through outbreeding depression. Outbreeding depression may occur by excessive straying of hatchery fish, spawning of non-local broodstock at the hatchery, or through transfers of stocks between hatcheries. If hatchery fish stray at rates or numbers that are high compared to naturally producing stocks, then hatchery strays may reduce between-population genetic diversity by interbreeding with distant populations. Hatchery spawning of two or more populations may directly result in hybridization at the hatchery. Between-population genetic variability could also be reduced by transferring gametes, juveniles, or adults between hatcheries. Loss of between-population genetic variability due to outbreeding depression can lower the genetic fitness of the natural population by breaking up locally-adapted gene complexes that work together to increase fitness (Lynch 1991, Allendorf and Waples 1996) and by combining genes from different sources that do not work well together (Emlen 1991).

Domestication selection. Selection pressures in the hatchery environment that are relaxed or otherwise different from the natural environment may cause genetic differences between hatchery and natural stocks through a process called domestication selection.

> Domestication selection can result in the survival of certain individuals in a hatchery environment that, under completely natural conditions, would have perished. Within the complete cycle of artificial production, these "marginal" individuals may then contribute their genes to their progeny, which may in turn exhibit a decreased ability to survive under natural conditions (Vincent 1960). Domestication selection causes a hatchery stock to diverge genetically from the local/donor population; this is thought to decrease the fitness of the hatchery population in the wild.

It is important to distinguish genetic changes associated with fish culture practices (loss of between and within population variation) from genetic changes caused by the hatchery environment (domestication selection). For example, fish culture practices such as broodstock transfers, broodstock selection, spawn timing, and release location can be modified to eliminate or minimize negative genetic impacts by changing hatchery operations. The Service has implemented several 'genetically conscious' management practices to minimize genetic risks associated with fish culture practices including: 1) collecting and spawning broodstock for all propagated stocks across the range of run and spawn timing; 2) spawning large numbers of broodstock (5,000 for fall chinook, 540 for late-fall chinook, and 400 for steelhead trout); 3) no deliberate selection (except to distinguish between stocks, e.g., late-fall and fall chinook) for particular phenotypic characteristics is used to choose broodstock; 4) a one to one mating scheme is used (i.e., one male fertilizes one female); and, 5) the majority of hatchery juveniles are released on-site or within the upper Sacramento River to minimize straying (these measures are discussed in more detail in Sections 6, 7, and 10 and are not included in the remainder of this discussion).

In contrast, genetic changes resulting from domestication selection (e.g., little or no predation, increased density during rearing, simplified environment, decreased selection pressure) are considered to be an unavoidable consequence of artificial propagation (Reisenbichler and McIntyre 1986, Lichatowich and McIntyre 1987, Waples 1991, Cuenco et al. 1993, Utter et al. 1993, Campton 1995, Allendorf and Waples 1996). Domestication selection is unavoidable because selection pressures in the hatchery environment are largely different from those incurred by naturally produced fish, generally resulting in a much higher rate of survival for hatchery fish. Practically speaking, the effects of domestication selection cannot be eliminated because, if the survival benefit of rearing fish in a hatchery environment were eliminated, then hatchery fish would survive at the same rate as naturally produced fish. This would limit the usefulness of hatchery propagation programs. Busack and Currens (1995) considered domestication selection to be one of the unavoidable "costs of using hatcheries". While it is not possible to eliminate entirely the effects of domestication selection, it may be possible to minimize domestication effects through regular infusion of natural-origin spawners as hatchery broodstock or incorporating some aspects of natural rearing (e.g., NATURES rearing strategies).

Managing potential genetic impacts to natural populations from hatchery propagation
The only strategy to ensure artificial propagation programs at Coleman NFH do not impart any deleterious genetic impacts on co-occurring natural populations of Pacific salmonids is to

terminate the hatchery programs. However, cessation of the hatchery propagation programs at Coleman NFH would result in failure of the Service to fulfill it's responsibility to mitigate for negative effects resulting habitat losses caused by Shasta Dam, and would have unknown and potentially harmful effects to chinook salmon and steelhead trout populations in the upper Sacramento River system. For example, hatchery chinook salmon and steelhead trout originating from Coleman NFH currently comprise a large portion of total escapement to the upper Sacramento River. Based solely upon abundance, hatchery-origin chinook salmon and steelhead trout likely contain a large portion of the total genetic diversity remaining within each upper Sacramento River stocks. Therefore, hatchery-origin chinook salmon and steelhead trout from Coleman NFH may serve as a "genetic storehouse," and termination of the propagation programs at Coleman NFH could potentially cause dramatic reductions in genetic variability for remaining stocks.

Although the potential exists for hatcheries to cause adverse genetic impacts to natural populations, most fishery managers understand the necessity for and role of hatchery propagation. Even as many of the factors that have caused salmonid populations to decline are being corrected (largely through harvest restrictions and habitat improvements associated with programs such as CALFED and CVPIA), it appears likely that hatchery propagation will continue to have a role in the upper Sacramento River. Hatchery propagation will continue to be used to compensate for lost and degraded habitats (e.g., upstream of Shasta Dam), and future salmonid production will be undoubtedly be comprised of both natural and hatchery components. Therefore, if we are to accept that hatchery propagation will continue to have a role in the upper Sacramento River ecosystem, it is imperative to identify the best strategy to minimize any adverse genetic consequences of artificial propagation

Strategies for minimizing negative genetic impacts to natural populations from hatchery propagation

In most cases where hatchery programs and natural populations coexist, managers have two general options for managing genetic impacts from artificial propagation programs: 1) manage the hatchery stock to be ecologically, behaviorally, morphologically, and genetically different from the natural population so that hatchery-origin adults do not (or cannot) spawn in the wild with natural adults (isolation); and, 2) manage the hatchery stock so that it is ecologically, behaviorally, morphologically, and genetically similar to the natural population, thereby minimizing the genetic risks when hatchery adults spawn in the wild with natural adults (integration).

> *Isolation* - The management strategy of isolation is intended to segregate the hatchery stocks from naturally spawning populations by separating adult spawners temporally, spatially, and/or reproductively, so that hatchery and natural populations do not (or cannot) interbreed in the wild. Available management options to accomplish long-term reproductive isolation include: manipulation of run timing through selective breeding; isolation of returning hatchery adults through incorporation of a terminal fishery or

broodstock collection location; complete marking of all hatchery stocks and selective spawning of only hatchery fish; and, outplanting of completely sterile juveniles.

Integration - This strategy is intended to minimize genetic and ecological differences between hatchery and natural stocks so that risks to natural populations are maintained within acceptable limits. The negative effects of gene flow from hatchery stocks to natural populations can be reduced by assuring that genetic differences between hatchery fish and the natural recipient population are as small as possible (Hindar et al. 1991). Hatchery management options that can be employed to minimize differences between hatchery and natural stocks include: obtaining founding broodstock from the locally adapted population and maintaining continual gene flow from the natural population (e.g., by incorporating naturally produced adults as broodstock).

Isolation as a strategy to minimize genetic risks to natural populations

Attempts to completely isolate (spatially, reproductively, or temporally) hatchery stocks at Coleman NFH from natural populations are unlikely to be successful because: 1) hatchery and natural fish will stray; 2) all hatchery fish (e.g., fall chinook) are not currently marked at Coleman NFH so hatchery fish cannot be distinguished from natural fish on an individual basis; 3) hatchery and natural stocks may spawn together because of proximal spawning areas; and, 4) hatchery and natural stocks have inherent variability in run and spawn timing. The inability to control all of these and other factors would likely preclude successful implementation of the isolation strategy.

For example, reproductive isolation is problematic. Sterilization programs are still largely experimental and may even be detrimental if large numbers of sterile but sexually active male fish compete with fertile males for territory or mates, effectively reducing production by natural-origin adults. This strategy would also increase pressure on natural populations since hatchery adults would not be available for broodstock. In addition, all of the hatchery fish produced at Coleman NFH are not currently marked, so incorporating only hatchery-origin adults as broodstock would not be possible, at least for fall chinook salmon. Efforts to reproductively isolate hatchery stocks from natural stocks by selectively breeding a change in spawn timing would also be largely ineffective, and may even be detrimental, given the inherent variation in spawn timing and the likelihood that the hatchery stock would interbreed with one of the other stocks present in the system (e.g., if hatchery fall chinook were selectively bred to spawn later in the year to prevent spawning with spring chinook, straying hatchery fall chinook would likely spawn with late-falls or winters). Localization (spatially isolating the artificial propagation program) is also difficult where natural and hatchery populations coexist. Even under best-case scenarios of long-term rearing and on-site releases (as with Coleman NFH), some artificially-produced fish are will undoubtedly stray and possibly spawn with natural populations.

Integration as a strategy to minimize genetic risks to natural populations

Given that total isolation of hatchery stocks from natural populations is unlikely or even impossible when hatchery and natural populations coexist, some level of integration between hatchery and natural populations is desirable to minimize genetic risks to natural populations.

Researchers generally agree that incorporating natural broodstock is necessary to decrease divergence between hatchery and natural populations (e.g., Reisenbichler and McIntyre 1986, Lichatowich and McIntyre 1987, Cuenco et al. 1993, NMFS 2000), however, efforts to quantify the level of incorporation necessary to prevent large amounts of divergence are just beginning. Preliminary research indicates that natural adults should be incorporated as broodstock at the highest proportion possible (e.g., Harada et al. 1998). It is appropriate, however, to balance between genetic risks of hatchery propagation and reducing the effects of removing spawners from the natural population.

While the goals of the propagation programs are different for the various stocks of chinook salmon and steelhead trout propagated at Coleman NFH (i.e., mitigation for fall and late-fall chinook salmon, supplementation and mitigation for steelhead trout), each of the hatchery programs employs a similar genetic management strategy: integration of hatchery stocks with their respective naturally spawning population. Hatchery broodstocks were founded from indigenous, locally-adapted salmonid populations from the upper Sacramento River and Battle Creek. Furthermore, natural-origin adults have been incorporated regularly and frequently into the hatchery populations to avoid genetic divergence between hatchery and natural stocks. By using locally adapted broodstock as the hatchery's founding population and by continuously infusing natural-origin adults into the broodstock, the Service has attempted to reduce the genetic risks resulting from the artificial propagation programs and maintain a genetically fit hatchery population.

Another benefit of maintaining genetically integrated hatchery stocks at Coleman NFH is the option of using hatchery fish for conservation and recovery of imperiled salmonid populations, both for stocks that are currently depressed and stocks that may suffer future reductions of abundance. Cuenco et al. (1993) described three potential uses of artificial propagation for rebuilding natural fish populations: 1) to seed unoccupied habitats capable of supporting viable salmonid populations; 2) to increase abundance in sparsely seeded habitats above a minimum viable population size to decrease the risk of extirpation; and, 3) to decrease the time required to rebuild a depressed stock. Allendorf and Waples (1996) recognized an additional role for hatcheries in the conservation of natural fish populations, to avoid immediate extinction of endangered populations. For all of these applications of artificial propagation in rebuilding natural fish populations, it is essential that cultured stocks are biologically, ecologically, and genetically suited to their receiving environments. It is generally accepted that reproduction, growth, and survival will be optimized by mimicking those characteristics of the locally adapted natural population. To ensure that adaptive traits are as similar as possible between hatchery and natural populations, it, it is generally desirable to match and maintain the genetic lineages of the hatchery stock and the locally adapted natural population (Cuenco et al. 1993).

Using spatial isolation and genetic integration to minimize genetic risks to natural populations
While most aspects of the isolation strategy are not compatible with hatchery-natural integration efforts (e.g., reproductive isolation and temporal isolation), spatial isolation (or localization) may be used in conjunction with integration efforts to minimize risks of hatchery propagation to

natural populations in Battle Creek. With the exception of the steelhead trout program, the Service does not intend for hatchery-origin fish from Coleman NFH to spawn with natural adults in the wild. The Service is currently analyzing operational and management alternatives (see Attachment 3-3 for an outline of management alternatives) that would promote spatial separation of hatchery fish from Coleman NFH and natural salmonid stocks from Battle Creek (report by Harza, Inc. to be submitted near the end of 2001). These alternatives are: utilizing a different return corridor (e.g., Gover's ditch) into the hatchery and moving the steelhead trout and late-fall chinook programs to a facility on the mainstem Sacramento River. Each of these alternatives was proposed for analysis during the Re-evaluation process to reduce the ecological impacts of hatchery fish on Battle Creek. Implementation of one or both of these alternatives would not, however, necessarily determine whether to implement the isolation or the integration genetic management strategy at Coleman NFH. For example, moving the steelhead trout and late-fall chinook production programs to a mainstem Sacramento River hatchery facility would not necessitate a decision to collect and spawn only hatchery-origin broodstock. Implementation of this alternative would, however, largely change the location where integration occurs (e.g., from Battle Creek to the mainstem Sacramento River) and may also decrease the ability of the Service to control the level of integration between hatchery and natural populations because the broodstock collection facility at a mainstem hatchery would likely not be as effective as the current situation in Battle Creek.

Genetic baseline: assessment of current genetic structure, integrity, and similarity of hatchery and natural populations in Battle Creek

Artificial production has been conducted in the Battle Creek watershed for over a century, beginning in 1895 with fall chinook salmon production and the construction of the Battle Creek Egg Taking Station. Fall chinook production was shifted to Coleman NFH in 1942 following the construction of that facility, and propagation of additional runs (e.g., late-fall, spring, and winter chinook salmon and steelhead trout) was subsequently initiated.

Currently, hatchery and natural stocks in the Battle Creek and the upper Sacramento River comprise a mixed population, including commingling and spawning together naturally as adults. Since the construction of Coleman NFH, natural- and hatchery-origin chinook salmon and steelhead trout have been incorporated as broodstock. Coleman NFH broodstock have been collected in Battle Creek and at the Keswick Dam fish trap in the mainstem Sacramento River. Natural-origin late-fall chinook salmon broodstock were captured at the Keswick Dam fish trap until 1997. Natural- and hatchery-origin fall chinook salmon and steelhead trout broodstock have been regularly collected in Battle Creek since the origins of the programs. The Service proposes to continue incorporating natural origin adults as hatchery broodstock to maintain a constant infusion of genetic material and minimize divergence from natural populations.

Banks et al. (2000) used microsatellite DNA methods to show substantial divergence among the four runs of salmon in the Central Valley. They found evidence of five major, more-or-less homogenous, populations of chinook salmon in the Central Valley: winter, spring, Butte Creek spring, fall and late fall. Key points from the Banks et al. (2000) research are: 1) microsatellite

DNA research shows hatchery-origin fall and late-fall chinook salmon adults and naturally-produced fall and late-fall chinook salmon adults appear to be genetically similar, at least based on the sub-set of loci examined[2]; and, 2) measurable genetic diversity exists between runs supporting the original phenotypic descriptions of Central Valley chinook salmon. Therefore, despite concern over irreversible loss of genetic heterogeneity due to habitat restrictions and hatchery influence, substantial genetic diversity and population structure remains. Banks et al. (2000) do, however, state that evidence for hybridization in hatcheries remains a pressing concern. All stocks of chinook salmon at Coleman NFH are included within the ESU's of their respective natural populations. Previous allozyme analyses of steelhead trout tissue have demonstrated Coleman NFH steelhead trout are genetically similar to the remaining natural population in Mill and Deer creeks. Based partly upon this research, the Coleman NFH steelhead trout stock is included within the ESU of Central Valley steelhead (Busby et al. 1996).

Conclusion

While evidence of behavioral, physiological, and genetic changes in hatchery populations compared to wild populations is increasing, it remains difficult or impossible to predict the genetic effects of hatcheries operating under various combinations of influences including: broodstock origins; fish stocks (differing life-history types); operational strategies; and levels of integration with natural stocks. In other words, "Although one can hypothesize that exposure to the hatchery environment, for even a small portion of the fish's life cycle, allows some genetic divergence from the natural genome, the degree and consequences of the change remain unknown." (Cuenco et al. 1993).

The level of genetic risk posed to natural salmonid populations resulting from interbreeding with hatchery-origin fish should be evaluated on a case-by-case basis, considering the multitude of factors that affect the level of similarity between hatchery and natural stocks. Most geneticists consider interbreeding among *exogenous or genetically diverged* hatchery and natural salmonid populations to be disadvantageous to the natural populations, resulting in a loss of fitness (see Waples 1991, Cuenco et al. 1993, Allendorf and Waples 1996, Reisenbichler and Rubin 1999, NMFS 2000). Salmonids have evolved in synchrony with their natural environments, and salmonid populations have adapted to the specific characteristics of their respective habitats (Scientific Review Team 1998). Spawning time, emergence timing, juvenile distribution, and marine orientation and distribution are not random processes, but occur in specific patterns of time and space for each population (Brannon 1984) and are undoubtedly characteristics that represent adaptation to ecological and geographic factors that cannot be replicated or improved through culture in the hatchery environment. Changes within cultured populations for characteristics such as growth rate, age at smolting, spawn timing, and various social behaviors may result in increased performance in hatcheries but may reduce performance and survival in the natural environment. In situations where interbreeding between hatchery and natural stocks is desirable, as in the case of the steelhead trout supplementation program, or when interbreeding is unavoidable, as with fall and late-fall chinook salmon at Coleman NFH, it is clearly beneficial to minimize the genetic differences between hatchery and natural stocks.

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[2] Most of the microsatellite DNA loci examined are likely selectively neutral (i.e., non-protein coding). Therefore, these loci are not likely reflective of adaptive differences.

The role of the Service's fish production programs at Coleman NFH include mitigation for lost spawning habitats, supplementation of at-risk stocks, and, potentially, recolonization of populations in restored habitats. While conducting artificial propagation activities to fulfil these responsibilities, the Service is also obligated to ensure that negative impacts resulting from artificial propagation programs are minimized. The Service believes the hatchery genetic integration strategy discussed above will ensure that hatchery-origin chinook salmon and steelhead trout from Coleman NFH are integrated into the ecosystem, so negative impacts on natural populations are minimized. Every effort will be made to minimize potential impacts and maintain genetic integrity of the stock (the potential genetic risks and benefits of Coleman NFH operations are listed in Sections 1.9 and 1.10 under Performance Standards and Indicators B5 and R4).

Available literature suggests domestication selection will likely occur (and has occurred) despite all attempts to minimize this impact (e.g., Reisenbichler and McIntyre 1977). Genetic divergence between the hatchery and natural populations may occur very rapidly and may become more pronounced if the hatchery programs were to use exclusively hatchery-origin adults for broodstock. This would increase risks to the natural population following hatchery introgression in the natural environment. By using local natural populations as founding broodstock, eliminating out-of-basin transfers, and incorporating natural adults as broodstock for all of Coleman NFH's propagation programs, the Service intends to reduce negative genetic effects to natural populations in Battle Creek and the upper Sacramento River resulting from hatchery-origin adults spawning in the natural environment.

Although many unknowns still persist regarding the impacts of artificial propagation on natural populations, the Service will continue to incorporate best available information and technologies to minimize genetic risks. Genetic risks can theoretically be minimized as long as genetic differences between the hatchery and natural populations is initially small (i.e., using local broodstock), and specific breeding and rearing guidelines (i.e., spawning fish from all segments of the run; using large numbers of broodstock to limit founder effects, inbreeding, and genetic drift; maximizing survival of eggs and progeny to avoid losses of specific genotypes, etc.) are followed in hatchery programs (Meffe 1986, Reisenbichler et al. 1992, Simon 1991). Furthermore, the Service will make efforts to minimize domestication selection by systematically incorporating natural-origin adults as hatchery broodstock. Although these actions will not eliminate the potential for the hatchery fish to impart negative genetic impacts on natural populations, they will reduce the potential for genetic differences between the hatchery and natural populations which will, in turn, reduce the genetic risks to natural populations (Meffe 1986, Reisenbichler et al. 1992).

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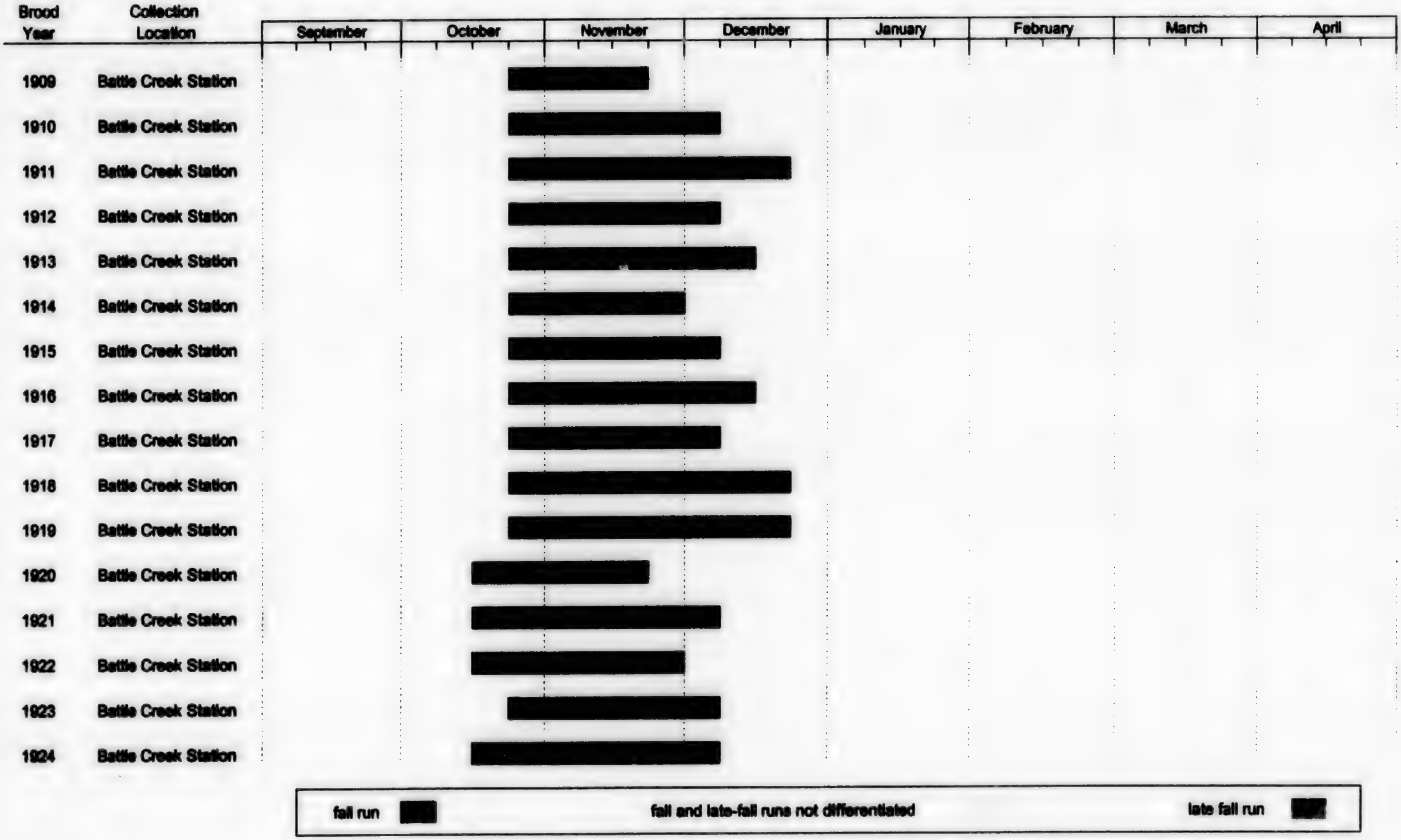
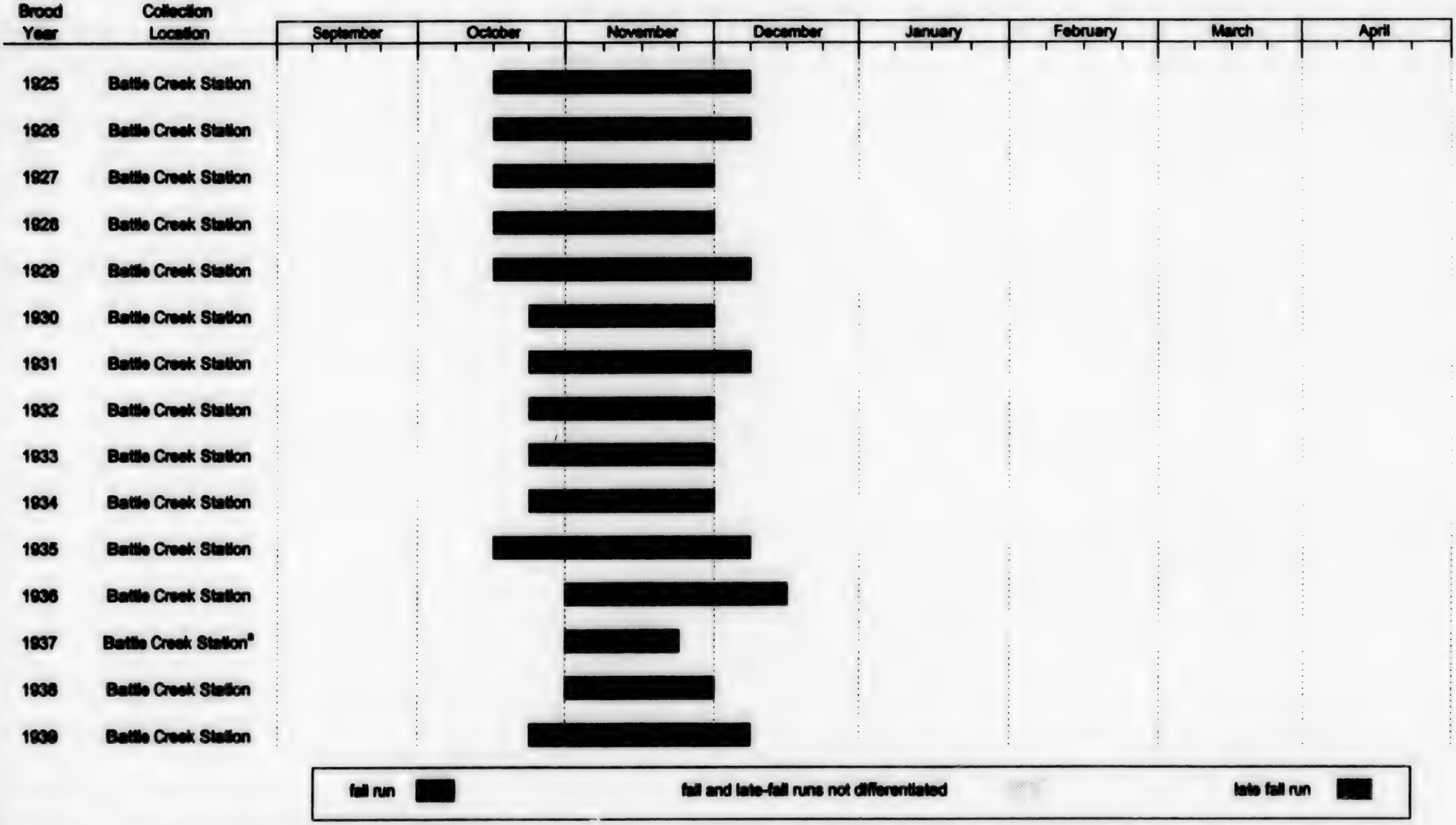
Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.

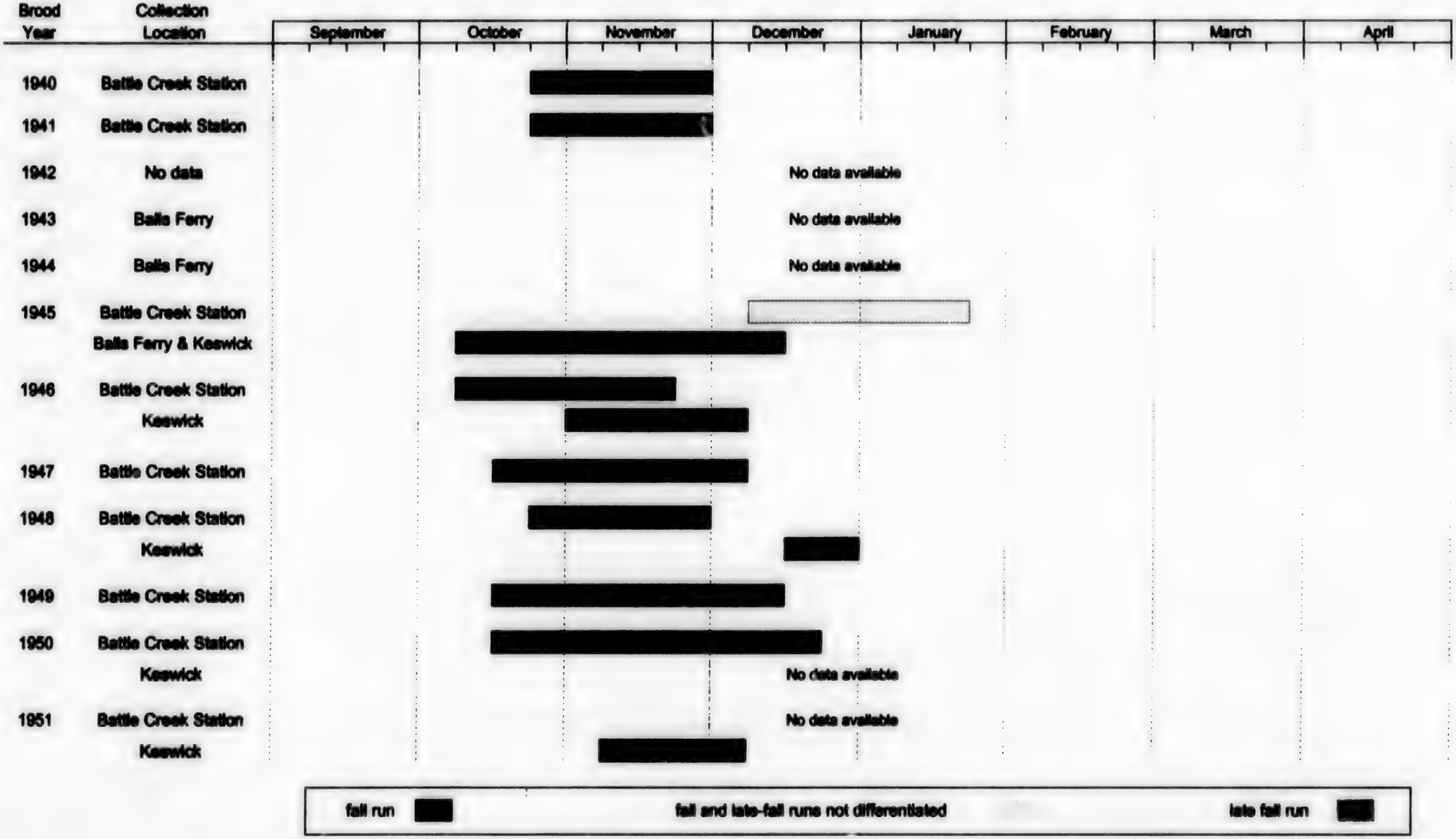


Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



[a] Heavy rain damaged Battle Creek Racks on 11/16/37. Seining was conducted on 11/16-11/19 on small tributaries to Battle Creek near the station.

Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



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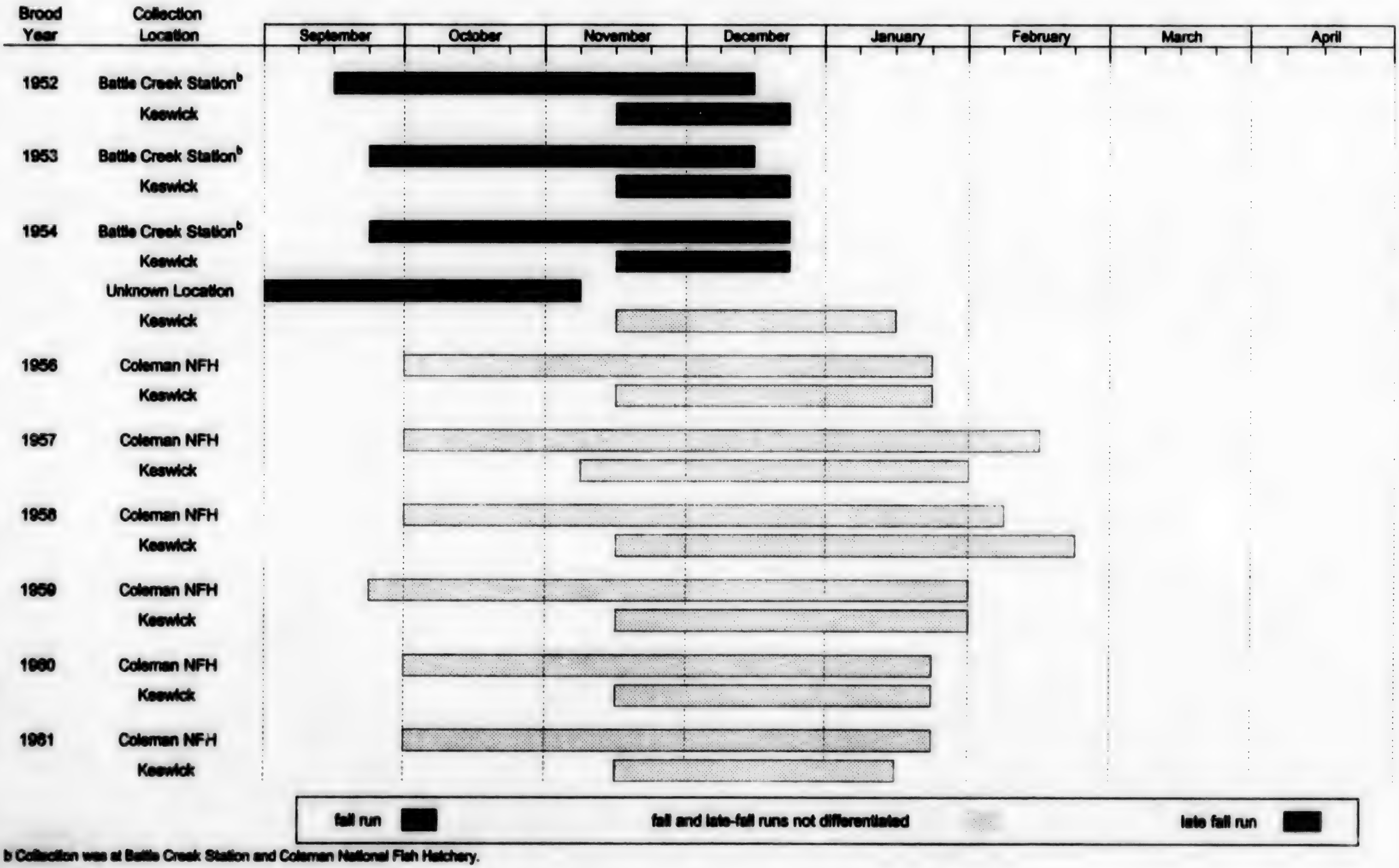
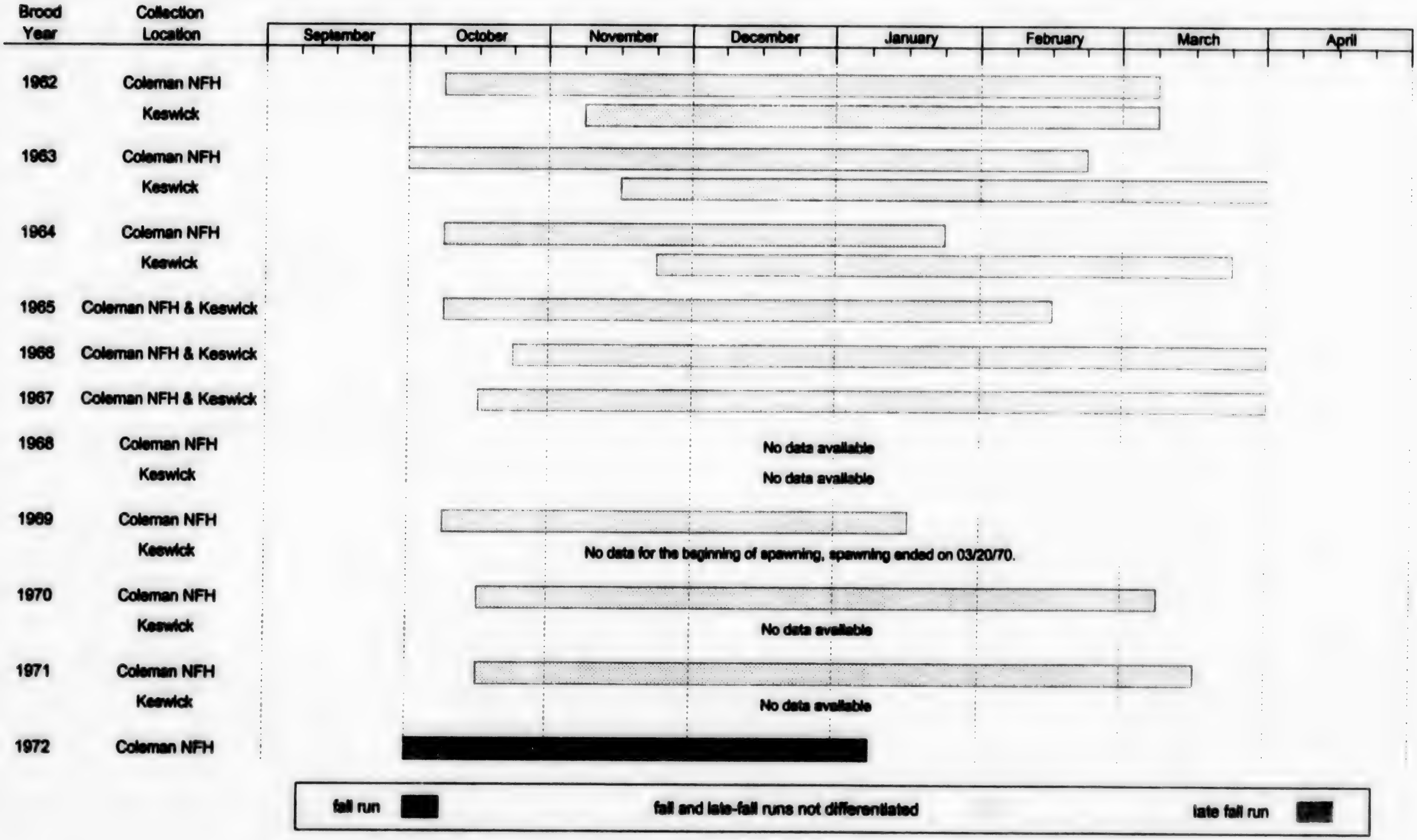
Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



b Collection was at Battle Creek Station and Coleman National Fish Hatchery.

Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



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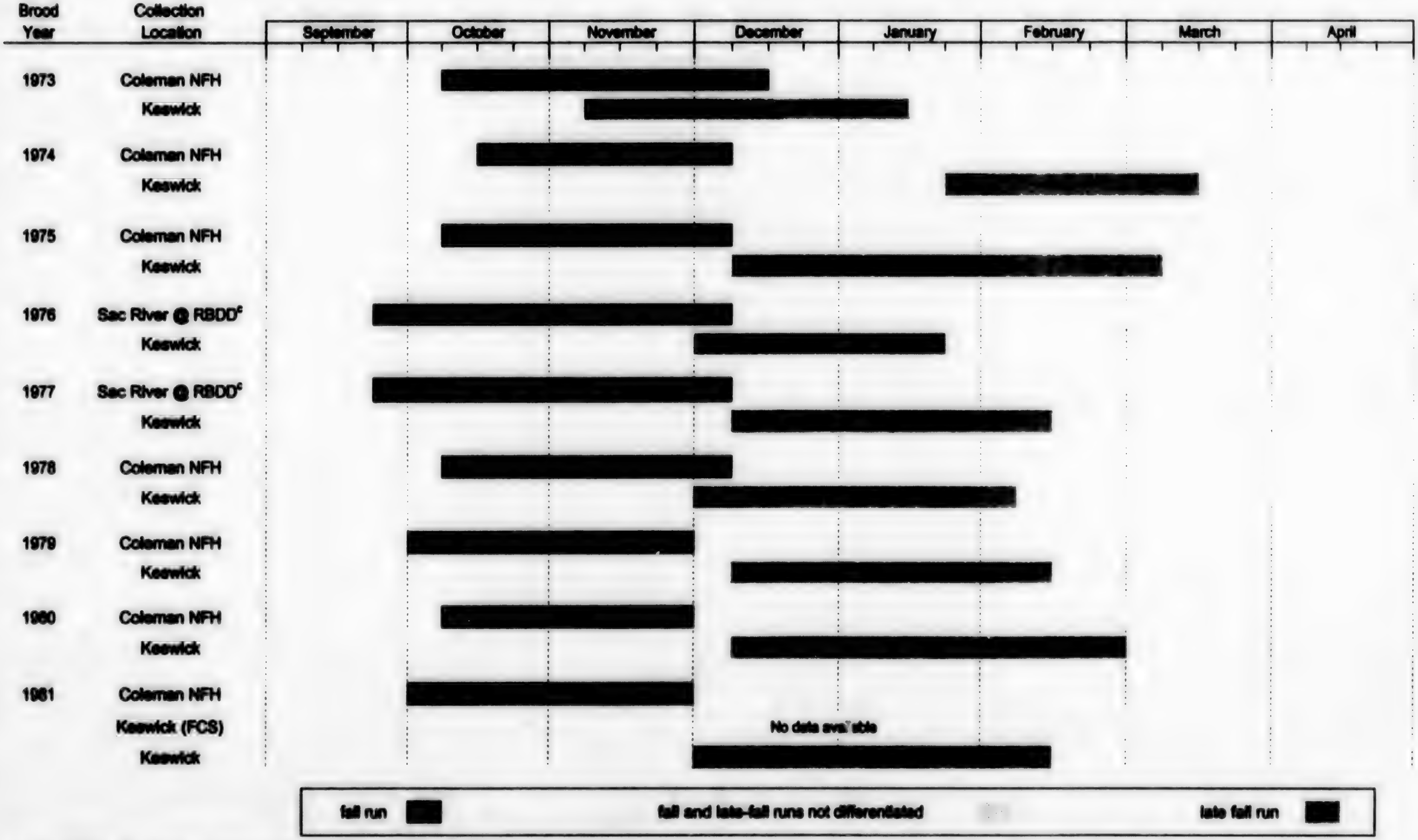
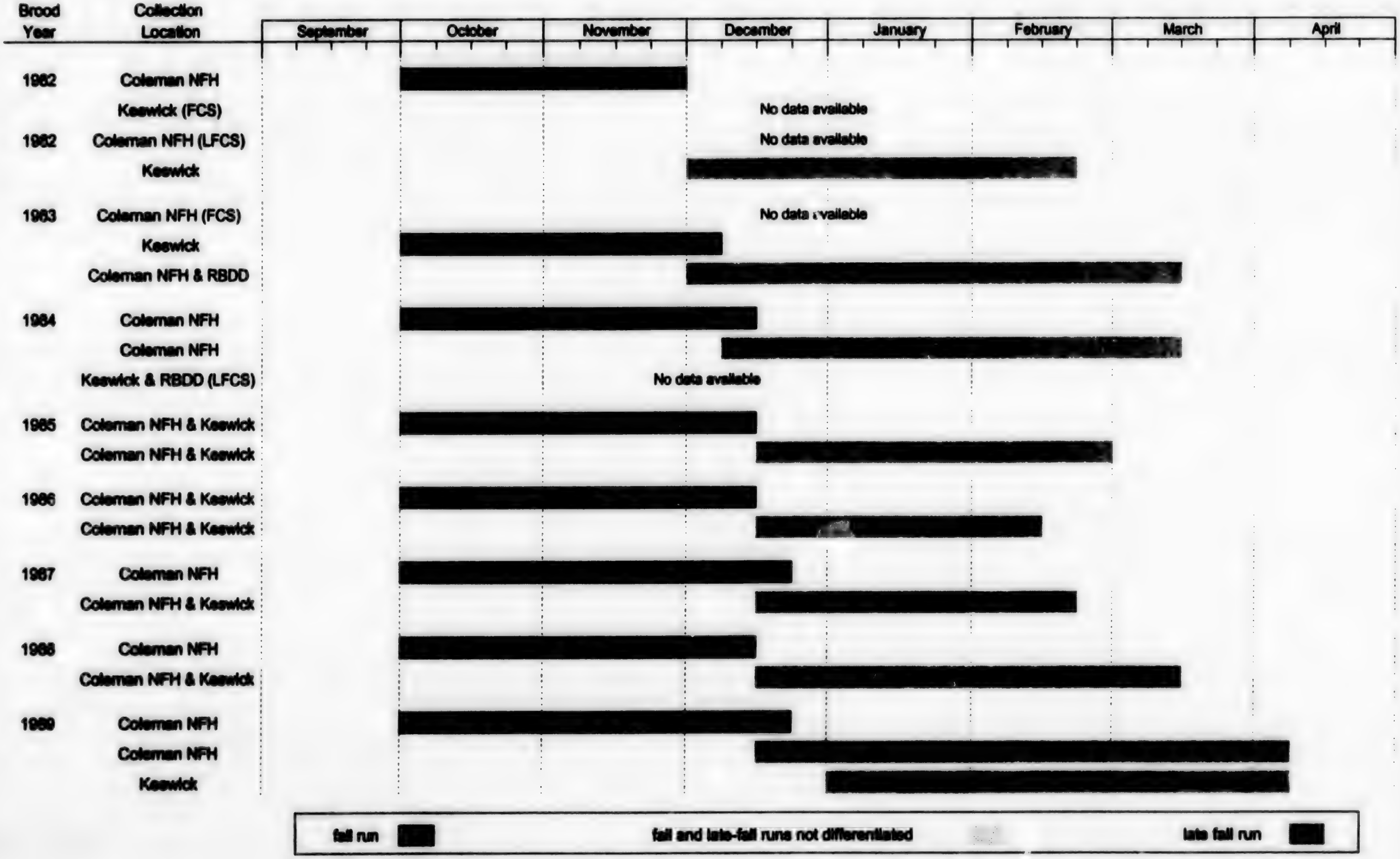
Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



[c] Drought years. Anadromous fish passage was blocked at the Red Bluff Diversion Dam (RBDD) due to unfavorable water temperature conditions in the upper Sacramento River. Fish were hauled by truck to CNFH.

Appendix 8A. **Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.**



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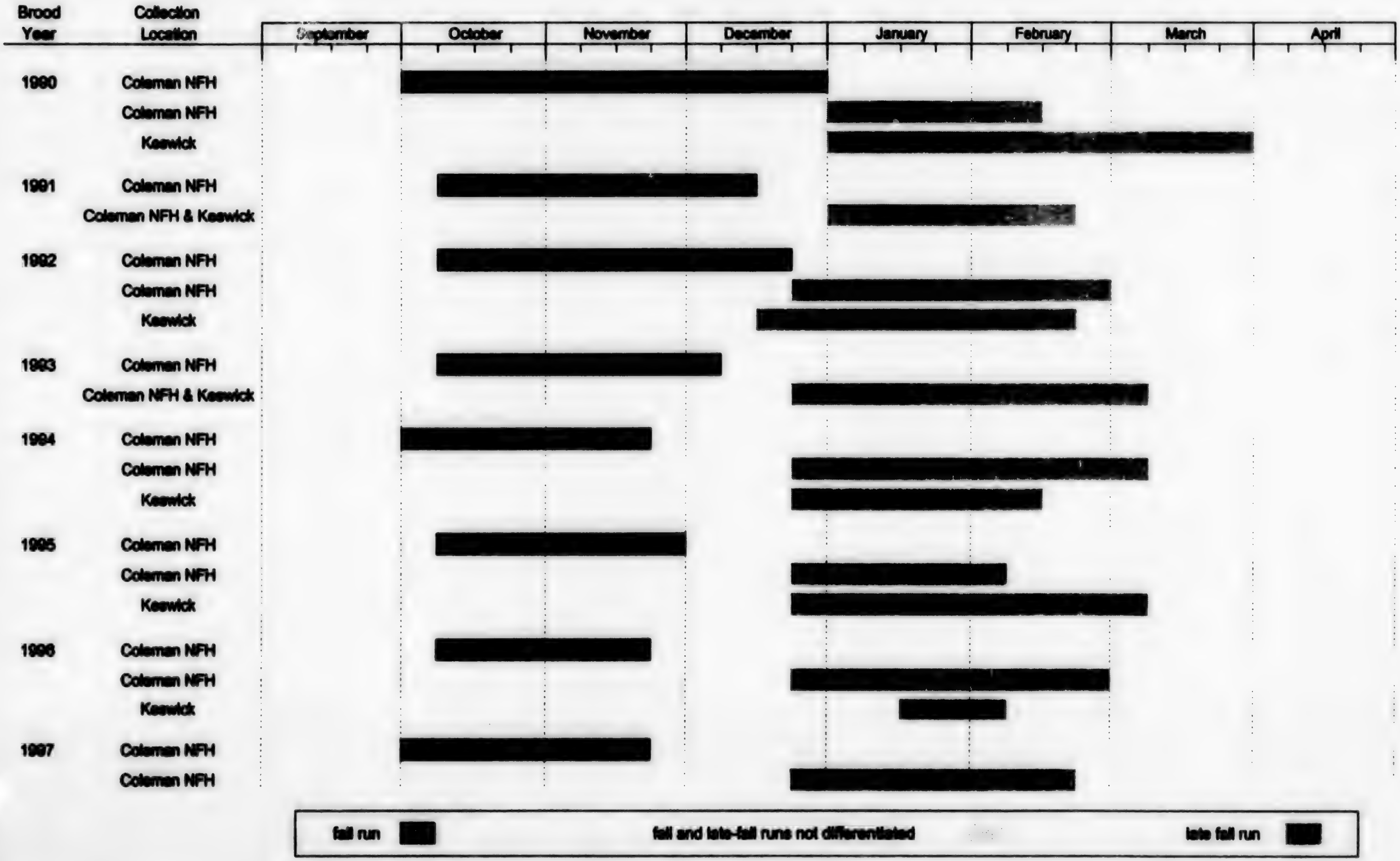
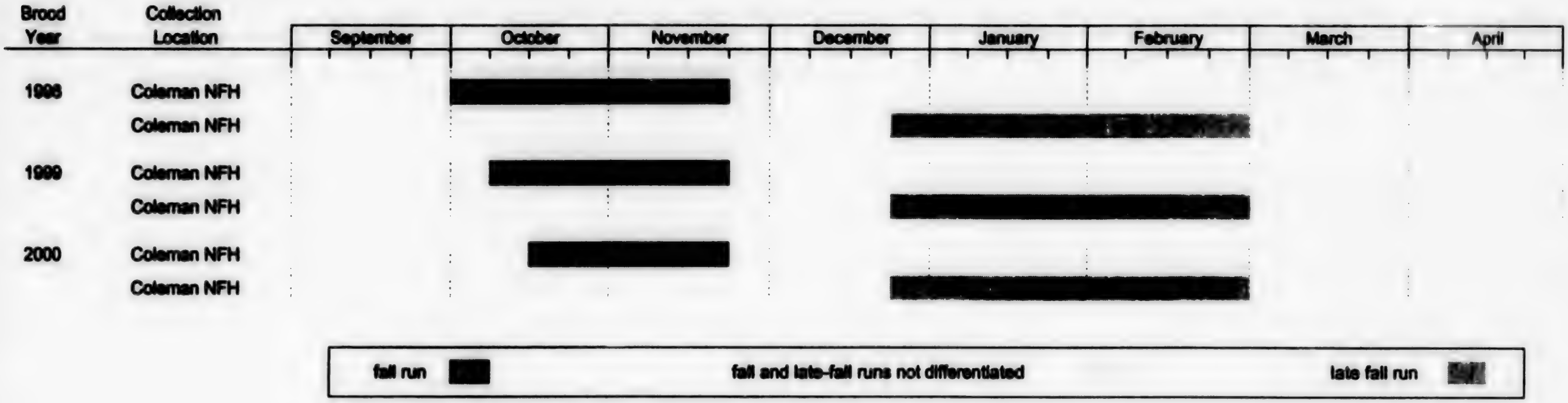
Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



Appendix 8A. Collection locations and approximate spawn timing of fall and late-fall chinook salmon for Battle Creek Egg Taking Station, 1909-1941, and Coleman National Fish Hatchery, 1942-1998.



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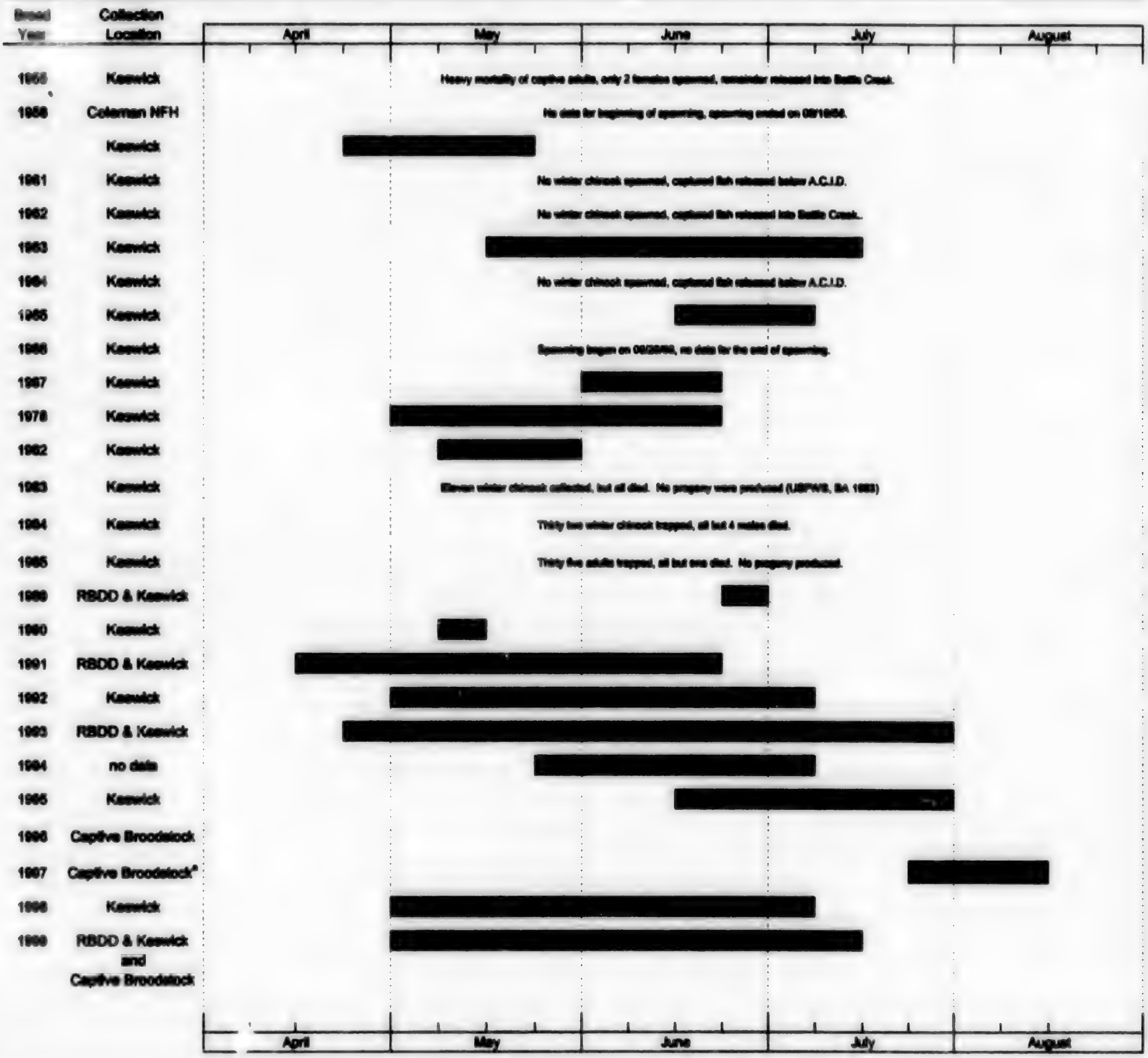
Appendix 8B. Collection location and spawn timing of winter chinook salmon for Coleman National Fish Hatchery, brood years 1955-1997 and Livingston Stone National Fish Hatchery, brood years 1997-1999.



[a]Captive broodstock, spawned at Bodega Marine Lab, incubated at Coleman NFH and transferred to Livingston Stone NFH.

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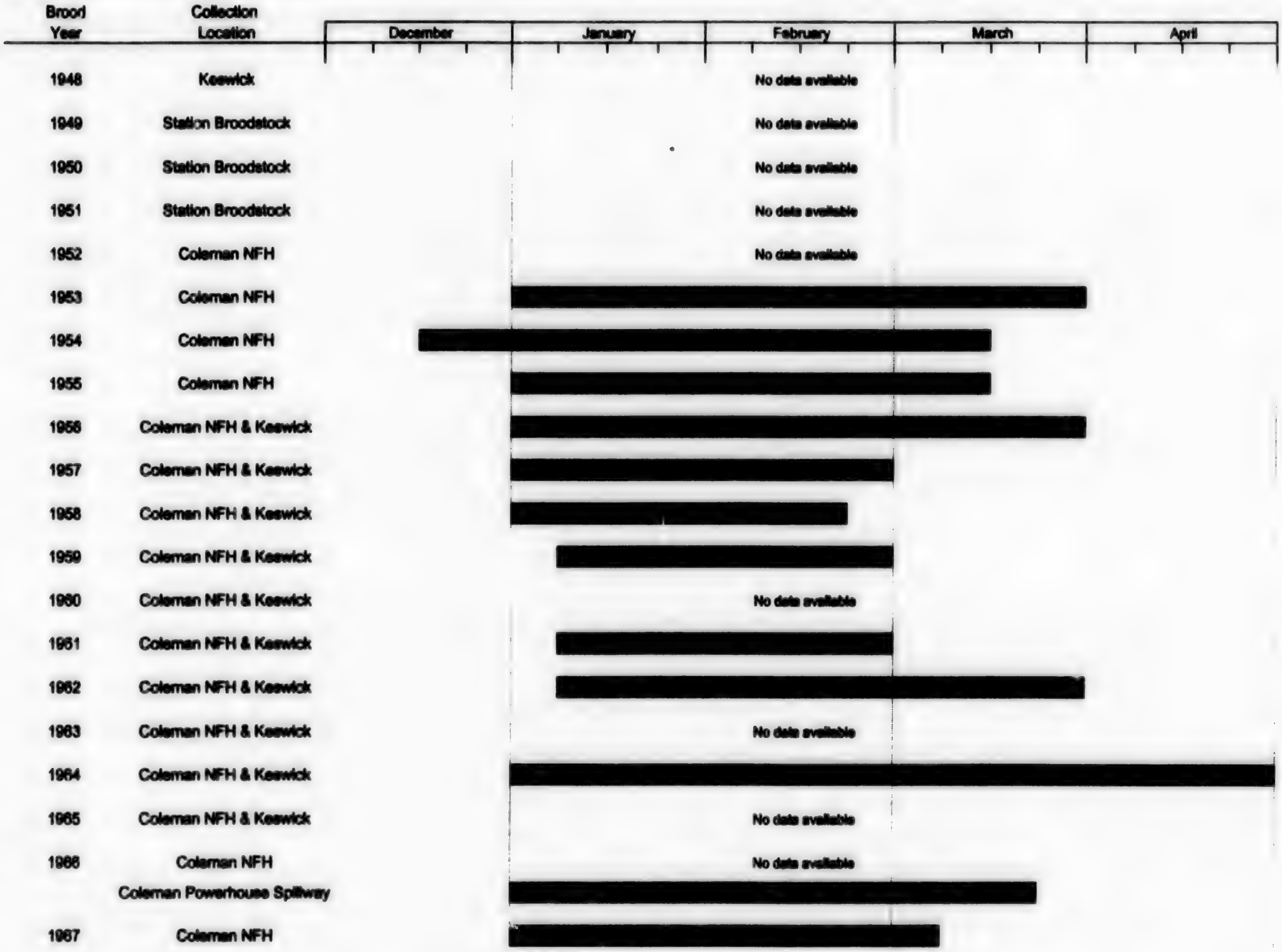
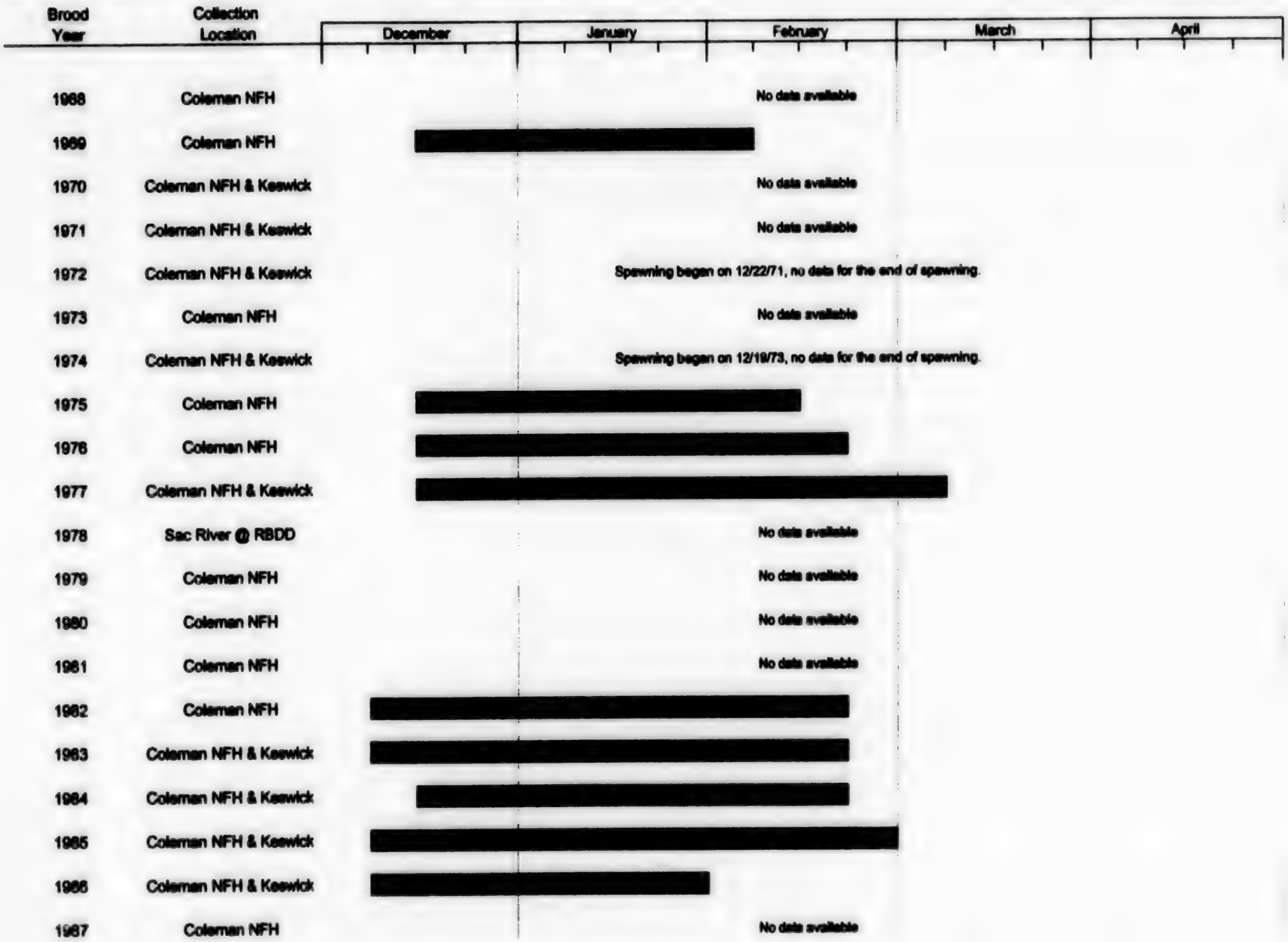
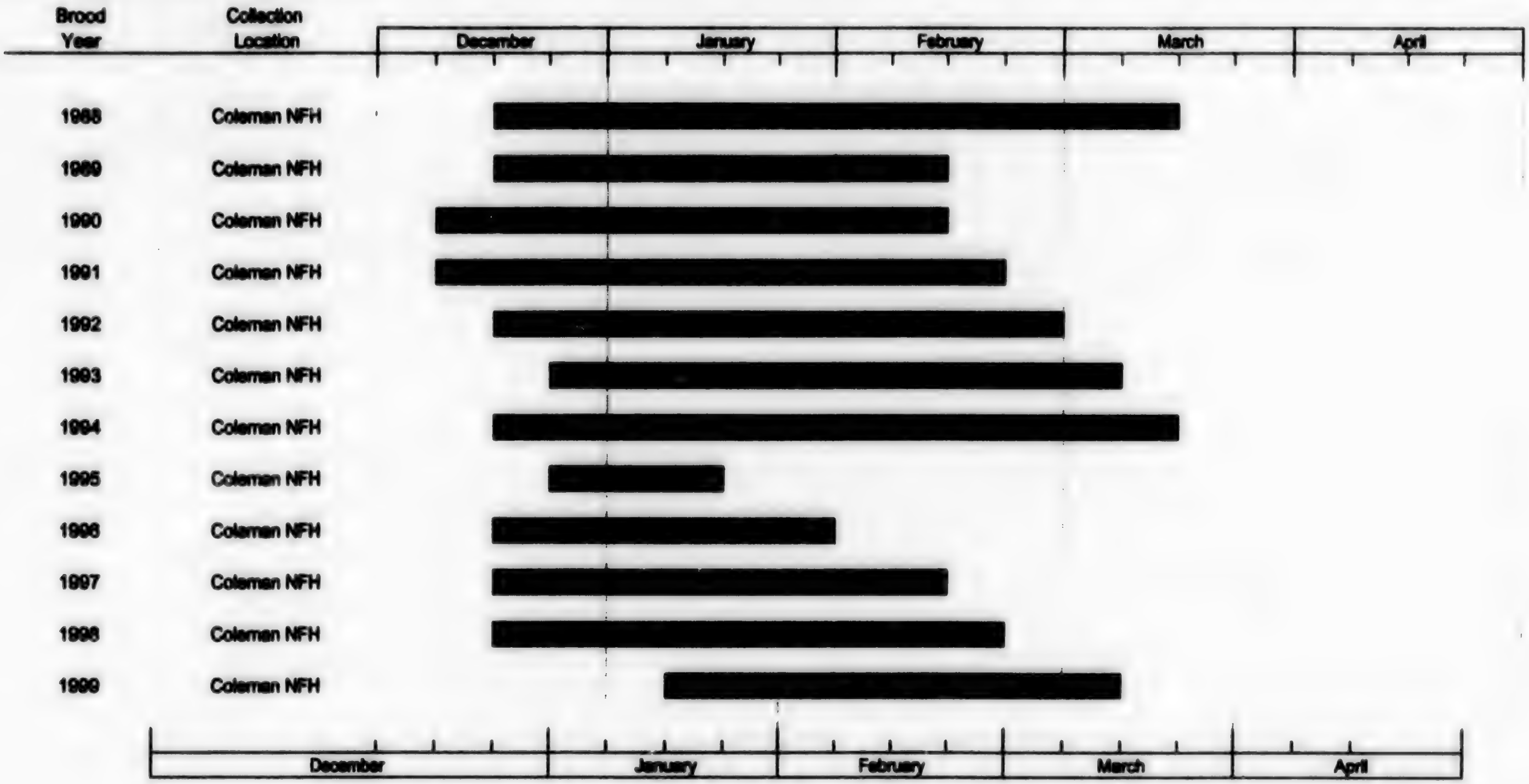
Appendix 8C. Collection locations and spawn timing of steelhead trout at Coleman National Fish Hatchery, brood years 1948-1999.



Appendix 8C. Collection locations and spawn timing of steelhead trout at Coleman National Fish Hatchery, brood years 1948-1999.



Appendix 8C. Collection locations and spawn timing of steelhead trout at Coleman National Fish Hatchery, brood years 1948-1999.



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Appendix 10A. **Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.**

Distribution Date													
	First	Last						Number	CWT	CWT	Size		
Month	Date	Date	Year	Species	Race	BY	Lot No.	Released	Status	Code	(Inches)	(No.)/lb	Release Location
			1941	Chinook				3,761,280	No CWT		ee	ee	
			1941	Chinook	Fall			801,600	No CWT		1		
			1941	Chinook	Spring			4,395,000	No CWT		1		
			1941	Chinook	Fall			506,576	No CWT		1.5		
			1946	Chinook	Spring		lot 8	87,863	No CWT		1.5		
			1946	Chinook	Spring		lot 8	24,930	No CWT		6		
12	27		1946	Chinook	Spring		lot 9	14,769	No CWT		1		
4	8	16	1946	Chinook	Spring		lot 9	66,629	No CWT		2		
3	27		1946	Chinook	Spring		lot 9	599,455	No CWT		2.5		
9	6	30	1946	Chinook	Spring		lot 9	94,286	No CWT		5		
10	2	14	1946	Chinook	Spring		lot 9	107,729	No CWT		5		
1	9		1946	Chinook	Fall	1945	lot 10	3,300	No CWT		1		
2	8		1946	Chinook	Fall	1945	lot 10	16,913,076	No CWT		2		
2	26		1946	Chinook	Fall	1945	lot 10	2,451,450	No CWT		2		
4	5	22	1946	Chinook	Fall	1945	lot 10	96,682	No CWT		4		
8	2	23	1946	Chinook	Fall	1945	lot 10	137,225	No CWT		4.5		Battle Creek
9	20	27	1946	Chinook	Fall	1945	lot 10	100,250	No CWT		4.5		Battle Creek
10	2	14	1946	Chinook	Fall	1945	lot 10	453,896	No CWT		5		Battle Creek
2	4	26	1946	Chinook	Fall	1945	lot 11	3,221,600	No CWT		1.5		
1	21	31	1946	Chinook	Fall	1945	lot 12	1,700,606	No CWT			1168	Battle Creek
2	1	21	1946	Chinook	Fall	1945	lot 12	6,001,086	No CWT		1-1.5		Battle Creek
12	3		1946	Chinook	Spring	1946	lot 13	1,800	No CWT		1		
1	16		1947	Chinook	Spring	1946	lot 12	157,782	No CWT		1		
2	1	20	1947	Chinook	Spring	1946	lot 12	888,334	No CWT		1.5 & 2		
9	15	29	1947	Chinook	Spring	1946	lot 12	297,338	No CWT		5 & 5.5		
1	3		1947	Chinook	Spring	1946	lot 13	2,660	No CWT		1.5		
2	1	20	1947	Chinook	Spring	1946	lot 13	802,427	No CWT		1.5 & 2		
3	4		1947	Chinook	Spring	1946	lot 13	16,126	No CWT		2		
10	1	7	1947	Chinook	Spring	1946	lot 13	277,205	No CWT		5 & 5.5		
2	16	18	1947	Chinook	Fall	1946	lot 14	1,357,799	No CWT		1.5		
3	3	17	1947	Chinook	Fall	1946	lot 14	8,267,539	No CWT		1.5		
10	8	10	1947	Chinook	Fall	1946	lot 14	301,009	No CWT		5.5		
3	13	28	1947	Chinook	Fall	1946	lot 15	13,806,801	No CWT		1.5		
4	1		1947	Chinook	Fall	1946	lot 15	19,449	No CWT		1.5		
10	10	14	1947	Chinook	Fall	1946	lot 15	289,982	No CWT		4 & 5		
3	26		1948	Chinook	Spring	1947	lot 17	74,654	No CWT		2		
10	19		1948	Chinook	Spring	1947	lot 17	43,236	No CWT		5		
3	17	26	1948	Chinook	Fall	1947	lot 18	6,432,451	No CWT		1.5 & 2		
4	8		1948	Chinook	Fall	1947	lot 18	104,660	No CWT		1.5 & 2		
9	13	29	1948	Chinook	Fall	1947	lot 18	796,763	No CWT		5		
10	13	18	1948	Chinook	Fall	1947	lot 18	760,733	No CWT		5		
			1949	Chinook	Fall	1948	lot 19	1,607,559	No CWT		2		

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
			1949	Chinook	Fall	1948	lot 19	1,915,492	No CWT		5		
4	7		1950	Chinook	Spring	1949	lot 22	32,000	No CWT		2		
9	22		1950	Chinook	Spring	1949	lot 22	151,378	No CWT		5		
			1950	Chinook	Fall	1949	lot 23	10,786,572	No CWT		1.5		
			1950	Chinook	Fall	1949	lot 23	100,000	No CWT		2		
			1950	Chinook	Fall	1949	lot 23	1,307,393	No CWT		5		
3	22		1951	Chinook	Spring	1950	lot 27	630,928	No CWT		2		Sacramento River
10	1		1951	Chinook	Spring	1950	lot 27	127,801	No CWT		5		Sacramento River
			1951	Chinook	Fall	1950	lot 28	8,107,405	No CWT		2		Sacramento River
			1951	Chinook	Fall	1950	lot 28	1,565,837	No CWT		5		Sacramento River
10	29		1952	Chinook	Fall	1952	lot 38	12,000	No CWT		ee	ee	Mill Creek, CA
1	21		1952	Chinook	Spring	1951	lot 32	789,949	No CWT		1		
			1952	Chinook	Fall	1951	lot 33	19,924,340	No CWT		1		
			1952	Chinook	Fall	1951	lot 33	1,483,784	No CWT		5		
			1953	Chinook	Fall	1952	lot 38	28,219,705	No CWT		1.5		
			1953	Chinook	Fall	1952	lot 38	2,754,095	No CWT		4		
			1953	Chinook	Fall	1953	lot 43	38,000	No CWT		ee	ee	Seattle, WA
			1953	Chinook	Fall	1953	lot 43	2,700	No CWT		ee	ee	Univ. of Wisconsin
			1953	Chinook	Fall	1953	lot 43	341,958	No CWT		1		
			1954	Chinook	Fall	1954	lot 46	151,273	No CWT		fry		Clear Creek
			1954	Chinook	Fall	1953	lot 43	38,700	No CWT		ee	ee	
			1955	Chinook	Fall	1953	lot 43	33,557,600	No CWT		1.5		Sacramento River
			1955	Chinook	Fall	1953	lot 43	2,238,860	No CWT		4		Sacramento River
			1955	Chinook	Fall	1953	lot 43	918,210	No CWT		5		Sacramento River
			1955	Chinook	Fall	1953	lot 43	2,000,000	No CWT		1		Mokelumne River
			1955	Chinook	Fall	1953	lot 43	100,000	No CWT		2		Clear Creek
			1955	Chinook	Fall	1953	lot 43	2,500	No CWT		2		Tracy Pumping Plant
			1955	Chinook	Fall	1953	lot 43	150	No CWT		4		Tracy Pumping Plant
			1955	Chinook	Fall	1954	lot 46/ 4CM	17,306,733	No CWT		2		Sacramento River
			1955	Chinook	Fall	1954	lot 46/ 4CM	2,713,173	No CWT		5		Sacramento River
			1955	Chinook	Fall	1954	lot 46/ 4CM	500,000	No CWT		1		Mokelumne River
10			1956	Chinook	Fall	1956	6CM	30,000	No CWT		ee	ee	Fisheries Biology
			1956	Chinook	Fall	1955	5CM	20,599,479	No CWT		2		Sacramento River
			1956	Chinook	Fall	1955	5CM	257,750	No CWT		3		Sacramento River
			1956	Chinook	Fall	1955	5CM	115,928	No CWT		4		Sacramento River
			1956	Chinook	Fall	1955	5CM	2,959,407	No CWT		5		Sacramento River
			1956	Chinook	Fall	1955	5CM	1,050,000	No CWT		1		Mokelumne River
			1956	Chinook	Fall	1955	5CM	1,000,000	No CWT		1		Russian River
2			1957	Chinook	Fall	1956	6CM	650,484	No CWT			513	Sacramento River
3			1957	Chinook	Fall	1956	6CM	335,000	No CWT			670	Sacramento River
3			1957	Chinook	Fall	1956	6CM	11,178,133	No CWT			608	Sacramento River
3			1957	Chinook	Fall	1956	6CM	250,000	No CWT		1		Clear Creek

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Appendix 10A. **Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.**

Distribution Date													
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	Size (Inches)	Size (No.)/lb	Release Location
3			1957	Chinook	Fall	1956	6CM	500,000	No CWT		1		Mill Creek, CA
4			1957	Chinook	Fall	1956	6CM	250,000	No CWT			719	Deer Creek, CA
5			1957	Chinook	Fall	1956	6CM	716,000	No CWT			358	Sacramento River
6			1957	Chinook	Fall	1956	6CM	367,112	No CWT			355	Sacramento River
7			1957	Chinook	Fall	1956	6CM	412,000	No CWT			208	Sacramento River
8			1957	Chinook	Fall	1956	6CM	560,800	No CWT		3		Sacramento River
9			1957	Chinook	Fall	1956	6CM	1,012,141	No CWT		4		Sacramento River
10			1957	Chinook	Fall	1956	6CM	2,214,648	No CWT			23	Sacramento River
12			1957	Chinook	Fall	1956	6CM	20,527	No CWT			12	Sacramento River
3			1958	Chinook	Fall	1957	7CM-56	889,990	No CWT			426	Sacramento River
4			1958	Chinook	Fall	1957	7CM-56	9,153,965	No CWT			78	Sacramento River
7			1958	Chinook	Fall	1957	7CM-5b	1,122,644	No CWT			88	Sacramento River
10			1958	Chinook	Fall	1957	7CM-56	2,912,528	No CWT			36	Sacramento River
12			1958	Chinook	Fall	1957	7CM-56	312,506	No CWT			18	Sacramento River
			1958	Chinook	Fall	1957	7CM-56	1,214,500	No CWT		ee	ee	Nimbus Hatchery
2			1959	Chinook	Fall	1958	8-CM-62	56,652	No CWT			752	Sacramento River
2			1959	Chinook	Fall	1958	8-CM-62	296,288	No CWT				Clear Creek
3			1959	Chinook	Fall	1958	8-CM-62	890,501	No CWT			1272	Sacramento River
4			1959	Chinook	Fall	1958	8-CM-62	427,758	No CWT			206	Sacramento River
5			1959	Chinook	Fall	1958	8-CM-62	656,257	No CWT			160	Sacramento River
6			1959	Chinook	Fall	1958	8-CM-62	2,893,240	No CWT			240	Sacramento River
10			1959	Chinook	Fall	1958	8-CM-62	922,793	No CWT			24	Sacramento River
11			1959	Chinook	Fall	1959	9-CM-66	25,000	No CWT		ee	ee	Mill Creek Fish. Res.
12			1959	Chinook	Fall	1958	8-CM-62	1,344,257	No CWT		4		Sacramento River
12			1959	Chinook	Fall	1959		165,368	No CWT		ee	ee	Mill Creek Fish. Res.
			1959	Chinook	Fall	1958	8-CAL-64	28,971	No CWT			281	
			1959	Chinook	Fall	1958	8-CM-62	14,932,795	No CWT		1		Sacramento River
			1959	Chinook	Winter	1958	8-CM-60	3,117	No CWT		4		Sacramento River
			1959	Chinook	Fall	1958	8-CM-62	1,753,750	No CWT		ee	ee	Nimbus Hatchery
			1959	Chinook	Fall	1959	9-CM-66	1,032,716	No CWT		ee	ee	
2			1960	Chinook	Fall	1959	9-CM-68	13,580,972	No CWT			964	Sacramento River
3			1960	Chinook	Fall	1959	9-CM-68	9,309,876	No CWT			1138	Sacramento River
4			1960	Chinook	Fall	1959	9-CM-68	6,856,595	No CWT			710	Sacramento River
5			1960	Chinook	Fall	1959	9-CM-68	579,000	No CWT			304	Sacramento River
10			1960	Chinook	Fall	1959	9-CM-68	4,505,551	No CWT			38	Sacramento River
1			1961	Chinook	Fall	1960	0-CN-74	254,928	No CWT			1128	Clear Creek
2			1961	Chinook	Fall	1960	0-CN-74	7,110,060	No CWT			613	Sacramento River
3			1961	Chinook	Fall	1960	0-CN-74	14,203,927	No CWT			457	Sacramento River
3			1961	Chinook	Fall	1960	0-CN-74	34,400	No CWT			800	Mill Creek Fish. Res.
4			1961	Chinook	Fall	1960	0-CN-74	5,195,425	No CWT			450	Sacramento River
5			1961	Chinook	Fall	1960	0-CN-74	764,236	No CWT			170	Sacramento River
6			1961	Chinook	Fall	1960	0-CN-74	1,328,136	No CWT			104	Sacramento River

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
7			1961	Chinook	Fall	1960	0-CN-74	234,900	No CWT			87	Sacramento River
10			1961	Chinook	Fall	1960	0-CN-74	4,089,140	No CWT			30	Sacramento River
12			1961	Chinook	Fall	1961	1-CN-78	500,000	No CWT		ee	ee	Mill Creek Fish Res.
12			1961	Chinook	Fall	1961	1-CN-78	3,649,940	No CWT		7	1128	Sacramento River
			1961	Chinook	Fall	1960	0-CAL-75	36,750	No CWT		2		Sacramento River
			1961	Chinook	Fall	1960	0-CAL-75	59,831	No CWT		2		Sacramento River
			1961	Chinook	Fall	1960	0-SC-73	285,847	No CWT		2		Sacramento River
1			1962	Chinook	Fall	1961	1-CN-78	4,049,852	No CWT		7	1287	
2			1962	Chinook	Fall	1961	1-CN-78	750,000	No CWT		7		Shasta Lake
3			1962	Chinook	Fall	1961	1-CN-78	6,904,374	No CWT			644	Sacramento River
3			1962	Chinook	Fall	1961	1-CN-78	760,611	No CWT			325	Transfer to Calif. Fish & Game
4			1962	Chinook	Fall	1961	1-CN-78	691,756	No CWT			306	Transfer to Calif. Fish & Game
5			1962	Chinook	Fall	1961	1-CN-78	164,655	No CWT			125	Transfer to Calif. Fish & Game
5			1962	Chinook	Fall	1961	1-CAL-79	50,000	No CWT			125	Sacramento River
5			1962	Chinook	Fall	1961	1-CAL-79	58,330	No CWT			124	Sacramento River
10			1962	Chinook	Fall	1961	1-CN-78	3,970,470	No CWT			37	Sacramento River
10			1962	Chinook	Fall	1961	1-CN-78	27,750	No CWT			37	Corp. of Eng.
1			1963	Chinook	Fall	1962	2-CN-83	250,000	No CWT		ee	ee	Mill Creek Fish. Res.
1			1963	Chinook	Fall	1962	2-CN-83	283,000	No CWT		ge	ge	Fish. Res. - Woodall
1			1963	Chinook	Fall	1962	2-CN-83	463,100	No CWT		ge	ge	Fish Res. - Parisot
2			1963	Chinook	Fall	1962	2-CN-83	54,000	No CWT			1227	Mill Creek Fish. Res.
2			1963	Chinook	Fall	1962	2-CN-83	1,467,622	No CWT			794	Sacramento River
3			1963	Chinook	Fall	1962	2-CN-83	12,187,679	No CWT			1062	Sacramento River
4			1963	Chinook	Fall	1962	2-CN-83	10,530,255	No CWT			460	Sacramento River
4			1963	Chinook	Fall	1962	2-CN-83	1,008,000	No CWT			899	Transfer to Calif. Fish & Game
5			1963	Chinook	Fall	1962	2-CN-83	5,571,807	No CWT			933	Sacramento River
5			1963	Chinook	Fall	1962	2-CN-83	509,000	No CWT			1000	Russian River
6			1963	Chinook	Fall	1962	2-CN-83	1,058,598	No CWT			475	Sacramento River
7			1963	Chinook	Fall	1962	2-CN-83	503,120	No CWT			380	Sacramento River
7			1963	Chinook	Winter	1963	3-CN-88	50,000	No CWT		ee	ee	Australia
8			1963	Chinook	Fall	1962	2-CN-83	278,029	No CWT			39	Sacramento River
9			1963	Chinook	Fall	1962	2-CN-83	604,835	No CWT			39	Sacramento River
10			1963	Chinook	Fall	1962	2-CN-83	3,198,076	No CWT			39	Sacramento River
11			1963	Chinook	Fall	1962	2-CN-83	1,113,750	No CWT			41	Sacramento River
11			1963	Chinook	Fall	1962	2-CN-83	63,000	No CWT			26	Russian River
12			1963	Chinook	Winter	1962	1-CN-82	34,516	No CWT		5		Sacramento River
12			1963	Chinook	Fall	1962	2-CN-83	357,000	No CWT			32	Sacramento River
12			1963	Chinook	Fall	1962	2-CN-83	112,000	No CWT			28	Clear Creek
1			1964	Chinook	Fall	1963	4-CN-89	60,000	No CWT		ge	ge	Mill Creek Fish. Res.
2			1964	Chinook	Winter	1963	3-CN-88	73,000	No CWT			88	Sacramento River
3			1964	Chinook	Fall	1963	4-CN-89	1,000,000	No CWT			1000	Sacramento River
5			1964	Chinook	Fall	1963	4-CN-89	368,000	No CWT				Russian River

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Data											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
7			1964	Chinook	Fall	1963	4-CN-89	605,500	No CWT			48	Sacramento River
8			1964	Chinook	Fall	1963	4-CN-89	1,134,000	No CWT			36	Sacramento River
10			1964	Chinook	Fall	1963	4-CN-89	3,300	No CWT			33	Fish. Res. - Tiburon
10			1964	Chinook	Fall	1963	4-CN-89	1,452,300	No CWT			34	Sacramento River
11			1964	Chinook	Fall	1963	4-CN-89	59,400	No CWT			54	Russian River
11			1964	Chinook	Fall	1963	4-CN-89	557,400	No CWT			38	Sacramento River
12			1964	Chinook	Fall	1963	4-CN-89	2,076,600	No CWT			73	Sacramento River
2			1965	Chinook	Fall	1964	5-CN-93	1,229,000	No CWT			95	Sacramento River
3			1965	Chinook	Fall	1964	5-CN-93	8,500,000	No CWT			689	Sacramento River
4			1965	Chinook	Fall	1964	5-CN-93	3,149,000	No CWT			605	Sacramento River
6			1965	Chinook	Fall	1964	5-CN-93	30,000	No CWT			500	Trans. Calif. Fish & Game
6			1965	Chinook	Fall	1964	5-CN-93	331,000	No CWT			99	Sacramento River
8	4	10	1965	Chinook	Fall	1964	5-CN-93	240,000	No CWT		3-4	38	Sacramento River
8	5	9	1965	Chinook	Fall	1964	5-CAL-94	220,000	No CWT		3	42	Sacramento River
8	11		1965	Chinook	Fall	1964	5-CN-93	65,000	No CWT		4	41	Red Bluff - Sacramento River
9	1	10	1965	Chinook	Fall	1964	5-CN-93	412,000	No CWT		4	32	Princeton - Sacramento River
9	10		1965	Chinook	Fall	1964	5-CN-93	36,000	No CWT		4	36	Red Bluff - Sacramento River
10	4	21	1965	Chinook	Fall	1964	5-CN-93	1,183,900	No CWT		3-4	41	Jelly's Ferry - Sacramento River
10	4	11	1965	Chinook	Fall	1964	5-CN-93	134,500	No CWT		3	42	Ball's Ferry - Sacramento River
11	2	30	1965	Chinook	Fall	1964	5-CN-93	3,083,600	No CWT		3-5	41	Jelly's Ferry - Sacramento River
3	24		1966	Chinook	Fall	1965	6-CN-1	222,000	No CWT		1	1,110	Clear Creek
5	5	13	1966	Chinook	Fall	1965	6-CN-1	360,300	No CWT		2	313	Princeton - Sacramento River
5	13	20	1966	Chinook	Winter	1965	5-CN-98	53,000	No CWT		4	30	Princeton - Sacramento River
7	20	29	1966	Chinook	Fall	1965	6-CN-1	570,800	No CWT		3	106	Jelly's Ferry - Sacramento River
7	21	22	1966	Chinook	Fall	1965	6-CN-1	239,800	No CWT		3	79	Princeton - Sacramento River
8	2		1966	Chinook	Fall	1965	6-CN-1	56,000	No CWT		3	56	Red Bluff - Sacramento River
8	8	25	1966	Chinook	Fall	1965	6-CN-1	746,900	No CWT		3	37	Jelly's Ferry - Sacramento River
8	17	30	1966	Chinook	Fall	1965	6-CN-1	516,450	No CWT		3	48	Princeton - Sacramento River
8	30		1966	Chinook	Fall	1965	6-CN-1	106,250	No CWT		3	106	Battle Creek
9	1		1966	Chinook	Fall	1965	6-CN-1	47,500	No CWT		3	95	Red Bluff - Sacramento River
9	2		1966	Chinook	Fall	1965	6-CAL-2	178,000	No CWT		3	89	Battle Creek
9	6	21	1966	Chinook	Fall	1965	6-CN-1	697,600	No CWT		3	75	Sacramento River @ Battle Creek
9	6	19	1966	Chinook	Fall	1965	6-CN-1	871,100	No CWT		3	80	Jelly's Ferry - Sacramento River
9	6	16	1966	Chinook	Fall	1965	6-CN-1	1,163,750	No CWT		4	48	Princeton - Sacramento River
9	7	21	1966	Chinook	Fall	1965	6-CN-1	1,078,550	No CWT		3-4	42	Battle Creek
9	23		1966	Chinook	Fall	1965	6-CAL-2	153,000	No CWT		3	85	Sacramento River @ Battle Creek
10	17	28	1966	Chinook	Fall	1965	6-CAL-2	100,800	No CWT		4	32	Sacramento River @ Battle Creek
10	31		1966	Chinook	Fall	1965	6-CN-1	2,409,300	No CWT		3-4	69	Sacramento River @ Battle Creek
11	1	3	1966	Chinook	Fall	1965	6-CN-1	783,000	No CWT		3	60	Sacramento River @ Battle Creek
2	9		1967	Chinook	Winter	1966	6-CN-6	4,300	No CWT		3	72	Jelly's Ferry - Sacramento River
6	2		1967	Chinook	Fall	1966	7-CN-9	125,190	No CWT		3	78	Battle Creek
8	16	28	1967	Chinook	Fall	1966	7-CN-9	1,135,744	No CWT		4	45	Sacramento River @ Battle Creek

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
8	28	31	1967	Chinook	Fall	1966	7-CN-9	1,276,021	No CWT		3	74	Sacramento River @ Battle Creek
9	1	20	1967	Chinook	Fall	1966	7-CN-9	3,206,445	No CWT		3	70	Sacramento River @ Battle Creek
9	6	8	1967	Chinook	Fall	1966	7-CN-9	538,790	No CWT		4	49	Sacramento River @ Battle Creek
11	1		1967	Chinook	Fall	1967	8-CN-15	18,000	No CWT		ee	ee	Research - Kimberly Clark Corp.
2	1		1968	Chinook	Winter	1967	7-CN-13	16,176	No CWT		3	139	Sacramento River @ Battle Creek
5	27	28	1968	Chinook	Fall	1967	8-CN-15	424,500	No CWT		3	85	Sacramento River @ Battle Creek
6	4	28	1968	Chinook	Fall	1967	8-CN-15	1,870,060	No CWT		3	89	Sacramento River @ Battle Creek
7	1	17	1968	Chinook	Fall	1967	8-CN-15	681,292	No CWT		3	97	Sacramento River @ Battle Creek
8	1	27	1968	Chinook	Fall	1967	8-CN-15	4,442,931	No CWT		3	85	Sacramento River @ Battle Creek
9	6	12	1968	Chinook	Fall	1967	8-CN-15	2,581,217	No CWT		3	88	Sacramento River @ Battle Creek
9	12		1968	Chinook	Fall	1967	8-CN-15	339,000	No CWT		3	70	Sacramento River
4	21		1969	Chinook	Fall	1968	9-CN-20	508,037	No CWT		3	80	Sacramento River @ Battle Creek
4	21		1969	Chinook	Fall	1968	9-CN-20	388,143	No CWT		3	74	Rio Vista
5	22	23	1969	Chinook	Fall	1968	9-CN-20	193,727	No CWT		3	86	Rio Vista
5	22	23	1969	Chinook	Fall	1968	9-CN-20	185,537	No CWT		3	86	Sacramento River @ Battle Creek
6			1969	Chinook	Fall	1968	9-CN-20	4,703	No CWT		3	157	Research - Tiburon Marine Lab.
7	5		1969	Chinook	Fall	1968	9-CN-20	2,500	No CWT		3	100	Red Bluff - Sacramento River
8	1	14	1969	Chinook	Fall	1968	9-CN-20	2,875	No CWT		3	192	Research - Kimberly Clark Corp.
9	2		1969	Chinook	Fall	1968	9-CN-20	120	No CWT		4	60	Research - Kimberly Clark Corp.
9	2	12	1969	Chinook	Fall	1968	9-CN-20	1,301,317	No CWT		3-4	64	Sacramento River @ Battle Creek
9	3	5	1969	Chinook	Fall	1968	9-UC-23	414,569	No CWT		3	52	Rio Vista
9	4	12	1969	Chinook	Fall	1968	9-CN-20	871,081	No CWT		3-4	65	Rio Vista
9	4		1969	Chinook	Fall	1968	9-CN-20	106,876	No CWT		3		Rio Vista
10	21		1969	Chinook	Fall	1969	9-CN-26	15,600	No CWT		ee	ee	Research - Kimberly Clark Corp.
11	21		1969	Chinook	Fall	1969	9-CN-26	8,000	No CWT		ee	ee	Research - Tehama Colusa Fish Facilities
2	27		1970	Chinook	Fall	1969	9-CN-26	18,000	No CWT		ee	ee	Research - Kimberly Clark Corp.
2	27		1970	Chinook	Fall	1969	9-CN-26	250	No CWT		2	250	Research - Kimberly Clark Corp.
3	19		1970	Chinook	Fall	1969	9-CN-26	1,500	No CWT		2	375	Research - Tiburon Marine Lab.
3	24		1970	Chinook	Fall	1969	9-CN-26	25,000	No CWT		1	1,316	Battle Creek
3	26		1970	Chinook	Fall	1969	9-CN-26	140	No CWT		2	375	Research - Kimberly Clark Corp.
4	1		1970	Chinook	Fall	1969	9-CN-26	180	No CWT		2	90	Research - Kimberly Clark Corp.
4	13	14	1970	Chinook	Fall	1969	9-CN-26	1,031,406	No CWT		ee	ee	Transferred to State of Cal. - Oroville Hatchery
4	16		1970	Chinook	Fall	1969	9-CN-26	600	No CWT		2	300	Research - Tiburon Marine Lab.
4	27	30	1970	Chinook	Fall	1969	9-CN-26	703,242	No CWT		4	81	Rio Vista
4	27	30	1970	Chinook	Fall	1969	9-CN-26	648,448	No CWT		4	84	Sacramento River @ Battle Creek
4	29		1970	Chinook	Fall	1969	9-CN-26	2,591	No CWT		5	50	Research - Tiburon Marine Lab.
5	13	14	1970	Chinook	Fall	1969	9-CN-26	361,151	No CWT		4	97	Sacramento River @ Battle Creek
6	1	12	1970	Chinook	Fall	1969	9-CN-26	734,065	No CWT		4	124	Rio Vista
6	2	18	1970	Chinook	Fall	1969	9-CN-26	475,546	No CWT		4	98	Sacramento River @ Battle Creek
6	2	30	1970	Chinook	Fall	1969	9-CN-26	14,502	No CWT		2-4	264	Research - Tiburon Marine Lab.
7	20		1970	Chinook	Fall	1969	9-CN-26	150	No CWT		3	150	Research - Kimberly Clark Corp.
9	14	30	1970	Chinook	Fall	1969	9-CN-26	2,375,473	No CWT		3	57	Princeton - Sacramento River

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
9	15		1970	Chinook	Fall	1969	9-CN-26	668	No CWT		3	45	Battle Creek
10	1	7	1970	Chinook	Fall	1969	9-CN-26	581,558	No CWT		3	52	Princeton - Sacramento River
10	12		1970	Chinook	Fall	1969	9-CN-26	150	No CWT		3	50	Research - Kimberly Clark Corp.
10	22		1970	Chinook	Fall	1969	9-CN-26	63,000	No CWT		3	50	Sacramento River @ Battle Creek
1	19		1971	Chinook	Fall	1970	0-CN-31	4,500	No CWT		ee	ee	Research - Diamond International Corp.
1	20		1971	Chinook	Fall	1970	0-CN-31	200	No CWT		1		Research - Kimberly Clark Corp.
2	2		1971	Chinook	Fall	1969	9-CN-26	150	No CWT		6	19	Research - Kimberly Clark Corp.
2	10		1971	Chinook	Fall	1969	9-CN-26	35,598	No CWT		6	19	Sacramento River @ Battle Creek
2	16		1971	Chinook	Fall	1970	0-CN-31	3,000	No CWT		ee	ee	Display - Arroyo Grande H.S.
3	4		1971	Chinook	Fall	1970	0-CN-31	3,000	No CWT		ee	ee	Display - Arroyo Grande H.S.
3	18		1971	Chinook	Fall	1970	0-CN-31	200	No CWT		3	67	Research - Kimberly Clark Corp.
3	19		1971	Chinook	Fall	1970	0-CN-31	4,000	No CWT		ee	ee	Research - Diamond International Corp.
5	10	28	1971	Chinook	Fall	1970	0-CN-31	1,886,819	No CWT		4	77	Rio Vista
5	17	19	1971	Chinook	Fall	1970	0-CN-31	1,056,577	No CWT		4	74	Sacramento River @ Battle Creek
6	1	10	1971	Chinook	Fall	1970	0-CN-31	527,425	No CWT		3	85	Rio Vista
6	2	10	1971	Chinook	Fall	1970	0-CN-31	1,658,081	No CWT		3	90	Battle Creek
9	15	27	1971	Chinook	Fall	1970	0-CN-31	1,448,674	No CWT		4-5	40	Princeton - Sacramento River
9	28		1971	Chinook	Fall	1970	0-CN-31	1,170,587	No CWT		4	49	Battle Creek
1	20		1972	Chinook	Fall	1971	1-CM-37	2,755	No CWT		1	1,378	Research - Tehama Colusa Fish Facilities
3	15		1972	Chinook	Fall	1971	1-CM-37	4,000	No CWT		3	200	Display - Steinhart Aquarium
3	24		1972	Chinook	Fall	1971	1-CM-37	298,800	No CWT		3	166	Battle Creek
4	5		1972	Chinook	Fall	1971	1-UCA-38	120,000	No CWT		1	1,000	Battle Creek
4	5		1972	Chinook	Fall	1971	1-CM-37	1,863,351	No CWT		3	121	Sacramento River @ Battle Creek
4	10		1972	Chinook	Fall	1971	1-CM-37	300	No CWT		3	150	Research - Simpson Lee Corp.
4	13		1972	Chinook	Fall	1971	1-UCA-38	551,600	No CWT		3	131	Battle Creek
4	25		1972	Chinook	Fall	1971	1-UCA-38	146,575	No CWT		3	143	Rio Vista
4	30		1972	Chinook	Fall	1971	1-UCA-38	64,500	No CWT		2	430	Battle Creek
5	2	19	1972	Chinook	Fall	1971	1-UCA-38	783,429	No CWT		3	68	Battle Creek
5	3	16	1972	Chinook	Fall	1971	1-CM-37	700	No CWT		3	100	Research - Tiburon Marine Lab.
5	5	24	1972	Chinook	Fall	1971	1-CM-37	615,689	No CWT		2	919	Balls Ferry - Sacramento River
5	12	26	1972	Chinook	Fall	1971	1-UCA-38	960,500	No CWT		3	117	Rio Vista
5	19	24	1972	Chinook	Fall	1971	1-CM-37	631,190	No CWT		3	90	Battle Creek
5	22		1972	Chinook	Fall	1971	1-CM-37	200	No CWT		3	100	Research - Simpson Lee Corp.
5	25		1972	Chinook	Fall	1971	1-CM-37	266,770	No CWT		3	103	Rio Vista
6	1		1972	Chinook	Fall	1971	1-CM-37	188,000	No CWT		3	94	Rio Vista
6	1	28	1972	Chinook	Fall	1971	1-UCA-38	1,575,811	No CWT		3	114	Battle Creek
6	1	28	1972	Chinook	Fall	1971	1-UCA-38	1,239,942	No CWT		3	101	Rio Vista
6	16		1972	Chinook	Fall	1971	1-UCA-38	426,189	No CWT		3	107	Knights Landing - Sacramento River
7	5		1972	Chinook	Fall	1971	1-UCA-38	1,060	No CWT		3	106	Research - Tiburon Marine Lab.
7	11	12	1972	Chinook	Fall	1971	1-UCA-38	513,520	No CWT		3	98	Rio Vista
7	11	12	1972	Chinook	Fall	1971	1-UCA-38	203,500	No CWT		3	98	Battle Creek
7	11	12	1972	Chinook	Fall	1971	1-CM-37	2,062,183	No CWT		3	106	Battle Creek

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
7	19		1972	Chinook	Fall	1971	1-CM-37	200	No CWT		3	100	Research - Kimberly Clark Corp.
8	1	9	1972	Chinook	Fall	1971	1-CM-37	325,048	No CWT		3	107	Battle Creek
8	9		1972	Chinook	Fall	1971	1-CM-37	942,990	No CWT		3	98	Balls Ferry - Sacramento River
10	13	17	1972	Chinook	Fall	19.	2-CM-43	7,100	No CWT		ee	ee	Research - Diamond International Corp.
3	29		1973	Chinook	Fall	1972	2-CM-43	1,000	No CWT		2	333	Display - Steinhart Aquarium
4	2		1973	Chinook	Fall	1972	2-UCA-44	100	No CWT		1		Research - Diamond International Corp.
4	6		1973	Chinook	Fall	1972	2-CM-43	100	No CWT		3		Research - Diamond International Corp.
4	9	27	1973	Chinook	Fall	1972	2-CM-43	600	No CWT		2-3	120	Research - Simpson Lee Corp.
4	18		1973	Chinook	Fall	1972	2-UCA-44	5,085	No CWT		2	339	Battle Creek
4	19	27	1973	Chinook	Fall	1972	2-CM-43	573,774	No CWT		2-4	81	Battle Creek
5	3	29	1973	Chinook	Fall	1972	2-CM-43	2,395,201	No CWT		3	89	Battle Creek
5	4	21	1973	Chinook	Fall	1972	2-UCA-44	12,795	No CWT		2	298	Battle Creek
5	4	31	1973	Chinook	Fall	1972	2-CM-43	550	No CWT		3	110	Research - Simpson Lee Corp.
6	1		1973	Chinook	Fall	1972	2-CM-43	307,843	No CWT		4	77	Battle Creek
6	6		1973	Chinook	Fall	1972	2-UCA-44	117,912	No CWT		4	102	Lake Redding Park - Sacramento River
6	8	29	1973	Chinook	Fall	1972	2-CM-43	1,003,333	No CWT		3	89	Battle Creek
6	18	29	1973	Chinook	Fall	1972	2-UCA-44	1,077,925	No CWT		3	101	Battle Creek
6	19	27	1973	Chinook	Fall	1972	2-UCA-44	780,690	No CWT		3	112	Rio Vista
6	20	27	1973	Chinook	Fall	1972	2-UCA-44	1,500	No CWT		3	100	Research - Tiburon Marine Lab.
6	26		1973	Chinook	Fall	1972	2-CM-43	198,653	No CWT		[illegible]	91	Lake Redding Park - Sacramento River
6	28		1973	Chinook	Fall	1972	2-UCA-44	230,000	No CWT		[illegible]	100	Balls Ferry - Sacramento River
6	29		1973	Chinook	Fall	1972	2-CM-43	216,000	No CWT		3	90	Rio Vista
1	11		1974	Chinook	Fall	1973	3-CM-50	60	No CWT		1		Display - Shasta College
1	22		1974	Chinook	Fall	1973	3-CM-50	357,850	No CWT		2	850	Research - Tehama Colusa Fish Facilities
1	23	29	1974	Chinook	Fall	1973	3-CM-50	140,400	No CWT		2	836	Battle Creek
1	28		1974	Chinook	Fall	1973	3-UCA-51	412,270	No CWT		2	1,220	Research - Tehama Colusa Fish Facilities
2	11		1974	Chinook	Fall	1973	3-CM-50	20,000	No CWT		2	667	Battle Creek
2	21		1974	Chinook	Fall	1973	3-CM-50	250	No CWT		2		Research - Simpson Lee Corp.
3	4	22	1974	Chinook	Fall	1973	3-CM-50	750	No CWT		2	250	Research - Simpson Lee Corp.
3	4	15	1974	Chinook	Fall	1973	3-CM-50	2,700	No CWT		2-3	193	Research - Simpson Lee Corp.
3	15		1974	Chinook	Fall	1973	3-UCA-51	5,000	No CWT		2	556	Battle Creek
3	16	17	1974	Chinook	Fall	1973	3-UCA-51	20,804	No CWT		2	520	Battle Creek
3	28		1974	Chinook	Fall	1973	3-UCA-52	11,875	No CWT		2	475	Battle Creek
5	7	17	1974	Chinook	Fall	1973	3-CM-50	2,901,493	No CWT		2-4	85	Battle Creek
5	9		1974	Chinook	Fall	1973	3-CM-50	500	No CWT		3	100	Research - Simpson Lee Corp.
5	17		1974	Chinook	Fall	1973	3-UCA-51	293,595	No CWT		3	88	Battle Creek
5	30		1974	Chinook	Fall	1973	3-UCA-51	500	No CWT		4	63	Research - Simpson Lee Corp.
6	4	13	1974	Chinook	Fall	1973	3-UCA-52	1,471,356	No CWT		3	89	Rio Vista
6	5	13	1974	Chinook	Fall	1973	3-UCA-52	1,182,878	No CWT		3	89	Battle Creek
6	6	17	1974	Chinook	Fall	1973	3-UCA-51	1,025,480	No CWT		3	95	Rio Vista
6	7		1974	Chinook	Fall	1973	3-UCA-51	255,061	No CWT		4	69	Battle Creek
6	13	17	1974	Chinook	Fall	1973	3-UCA-51	556,493	No CWT		3	90	Battle Creek

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date													
	First	Last						Number	CWT	CWT	Size		
Month	Date	Date	Year	Species	Race	BY	Lot No.	Released	Status	Code	(Inches)	(No.)/lb	Release Location
6	13	28	1974	Chinook	Late-fall	1974	3-CM-55	1,686,593	No CWT		2	304	Battle Creek
6	14	27	1974	Chinook	Late-fall	1974	3-CM-55	1,100	No CWT		3	110	Research - Simpson Lee Corp.
6	24	28	1974	Chinook	Fall	1973	3-CM-50	1,502,317	No CWT		3	94	Battle Creek
11	12		1974	Chinook	Fall	1974	4-CM-56	6,000	No CWT		ee	ee	Research - Simpson Lee Corp.
12	15		1974	Chinook	Fall	1974	4-CM-56	1,000	No CWT		ee	ee	Display - San Jose School
4	3	18	1975	Chinook	Fall	1974	4-CM-56	650	No CWT		2	325	Research - Simpson Lee Corp.
4	24	30	1975	Chinook	Fall	1974	4-CM-56	179,840	No CWT		2-3	118	Battle Creek
4	30		1975	Chinook	Late-fall	1975	4-CM-57	15,600	No CWT		2	600	Battle Creek
5	6		1975	Chinook	Fall	1974	4-CM-56	246,315	No CWT		3	81	Battle Creek
5	8	29	1975	Chinook	Fall	1974	4-UCA-58	900	No CWT		3	150	Research - Simpson Lee Corp.
5	13		1975	Chinook	Late-fall	1975	4-CM-57	3,500	No CWT		2	500	Battle Creek
5	30		1975	Chinook	Fall	1974	4-UCA-58	100,000	No CWT		3	100	Battle Creek
6	3		1975	Chinook	Fall	1974	4-CM-56	288,600	No CWT		3-4		Red Bluff Diversion Dam
6	3		1975	Chinook	Fall	1974	4-UCA-58	168,650	No CWT		3		Red Bluff Diversion Dam
6	3	9	1975	Chinook	Fall	1974	4-UCA-58	319,088	No CWT		3		Battle Creek
6	3	9	1975	Chinook	Fall	1974	4-CM-56	1,194,807	No CWT		3		Battle Creek
6	9		1975	Chinook	Late-fall	1975	4-CM-57	7,500	No CWT		3		Battle Creek
6	12		1975	Chinook	Late-fall	1975	4-CM-57	1,070	No CWT		3	214	Research - Simpson Lee Corp.
6	25		1975	Chinook	Late-fall	1975	4-CM-57	5,000	No CWT		2		Battle Creek
7	16	31	1975	Chinook	Late-fall	1975	4-CM-57	1,250	No CWT		2-4	179	Research - Simpson Lee Corp.
8	7		1975	Chinook	Late-fall	1975	4-CM-57	300	No CWT		3	150	Research - Simpson Lee Corp.
9	2	18	1975	Chinook	Late-fall	1975	4-CM-57	1,863,988	Partial	080301	3-4	58	Battle Creek
10	3		1975	Chinook	Late-fall	1975	4-CM-57	120	No CWT		4	60	Display - Shasta College
10	21		1975	Chinook	Fall	1975	5-CM-63	6,000	No CWT		ee	ee	Research - Simpson Lee Corp.
12	2	3	1975	Chinook	Fall	1975	5-CM-63	24,000	No CWT		ee	ee	Transfer - California Dept. Fish and Game
1	8		1976	Chinook	Late-fall	1975	4-CM-57	10,085	No CWT		5	24	Balls Ferry - Sacramento River
2	13		1976	Chinook	Late-fall	1976	5-CM-65	6,000	No CWT		ee	ee	Research - Simpson Lee Corp.
2	18		1976	Chinook	Fall	1975	5-CM-63	3,000	No CWT		2	500	Battle Creek
3	1	15	1976	Chinook	Fall	1975	5-CM-63	700	No CWT		2-3	140	Research - Simpson Lee Corp.
3	19		1976	Chinook	Fall	1975	5-CM-63	10,000	No CWT		2	714	Battle Creek
3	19		1976	Chinook	Fall	1975	5-UCA-64	5,000	No CWT		2	714	Battle Creek
4	2		1976	Chinook	Fall	1975	5-UCA-64	10,950	No CWT		2	438	Battle Creek
4	13		1976	Chinook	Fall	1975	5-CM-63	105,723	No CWT		4	74	Battle Creek
4	19		1976	Chinook	Fall	1975	5-CM-63	450	No CWT		3	150	Research - Simpson Lee Corp.
5	5		1976	Chinook	Fall	1975	5-CM-63	13,500	No CWT		3	90	Battle Creek
5	14	28	1976	Chinook	Fall	1975	5-CM-63	433,090	Partial	080303, 080304, 080305	3	156	Lake Red Bluff - Sacramento River
5	14	28	1976	Chinook	Fall	1975	5-CM-63	403,232	Partial	080303, 080304, 080305	3	137	Above Red Bluff Diversion Dam - Sacramento River
5	14	28	1976	Chinook	Fall	1975	5-CM-63	401,018	Partial	080303, 080304, 080305	3	131	Below Red Bluff Diversion Dam - Sacramento River
5	25		1976	Chinook	Fall	1975	5-CM-63	600	No CWT		3	200	Research - Simpson Lee Corp.
6	1	7	1976	Chinook	Fall	1975	5-CM-63	1,205,384	No CWT		3	100	Battle Creek

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
6	1		1976	Chinook	Fall	1975	5-CM-63	124,230	No CWT		3	120	Above Red Bluff Diversion Dam - Sacramento River
6	1		1976	Chinook	Fall	1975	5-CM-63	39,270	No CWT		3	102	Below Red Bluff Diversion Dam - Sacramento River
6	1		1976	Chinook	Fall	1975	5-CM-63	49,770	No CWT		3	121	Lake Red Bluff - Sacramento River
6	7	25	1976	Chinook	Fall	1975	5-UCA-64	478,284	No CWT		3	101	Battle Creek
6	7	25	1976	Chinook	Late-fall	1976	5-CM-65	950	No CWT		3	119	Research - Simpson Lee Corp.
6	24	28	1976	Chinook	Fall	1975	5-UCA-64	938,300	No CWT		3	115	Rio Vista
7	30		1976	Chinook	Late-fall	1976	5-CM-65	500	No CWT		3	100	Research - Simpson Lee Corp.
9	10		1976	Chinook	Fall	1975	5-UCA-64	161,000	No CWT		4	55	Battle Creek
9	10		1976	Chinook	Fall	1975	5-CM-63	716,000	No CWT		4	50	Battle Creek
9	22		1976	Chinook	Fall	1975	5-UCA-64	87,000	No CWT		5	35	Battle Creek
9	22		1976	Chinook	Fall	1975	5-CM-63	117,000	No CWT		5	28	Battle Creek
10	7	20	1976	Chinook	Late-fall	1976	5-CM-65	397,483	Partial	060307	3-4	49	Battle Creek
10	12		1976	Chinook	Fall	1975	5-CM-63	7,573	No CWT		5	26	Clifton Court Forebay
10	18		1976	Chinook	Fall	1975	5-CM-63	58,766	No CWT		5		Sacramento River at Battle Creek
10	18	20	1976	Chinook	Fall	1975	5-CM-63	126,904	No CWT		4	39	South Fork Mokelumne River
10	18		1976	Chinook	Fall	1975	5-CM-63	39,396	No CWT		5	33	North Fork Mokelumne River
10	18	20	1976	Chinook	Late-fall	1976	5-CM-65	106,392	No CWT		4	48	Ryde - Sacramento River
10	18	20	1976	Chinook	Late-fall	1976	5-CM-65	125,733	No CWT		4	48	Steamboat Slough - Sacramento River
10	20		1976	Chinook	Fall	1975	5-CM-63	45,962	No CWT		5	33	Mokelumne River - Georgiana Slough
2	20		1977	Chinook	Fall	1976	6-CM-72	300	No CWT		1	150	Research - Simpson Lee Corp.
3	14		1977	Chinook	Fall	1976	6-CM-72	262	No CWT		3	175	Research - Simpson Lee Corp.
4	15		1977	Chinook	Fall	1976	6-CM-72	600	No CWT		3	200	Research - Simpson Lee Corp.
4	15		1977	Chinook	Fall	1976	6-CM-72	2,000	No CWT		1	1,230	Research - Tehama Colusa Fish Facilities
4	21	28	1977	Chinook	Fall	1976	6-CM-72	1,597,000	No CWT		3	93	Battle Creek
5	6	24	1977	Chinook	Fall	1976	6-CM-72	932,312	Partial	060008, 060009, 060010, 060011	3-4	86	Red Bluff - Sacramento River
5	9		1977	Chinook	Fall	1976	6-CM-72	500	No CWT		2	250	Research - Simpson Lee Corp.
5	12	31	1977	Chinook	Fall	1976	6-CM-72	4,072,980	No CWT		2-3	95	Battle Creek
5	24		1977	Chinook	Fall	1976	6-CM-74	800	No CWT		2	400	Research - Simpson Lee Corp.
5	31		1977	Chinook	Fall	1976	6-UCA-73	869,905	No CWT		3	115	Battle Creek
6	15	21	1977	Chinook	Fall	1976	6-UCA-73	1,096,809	No CWT		3	91	Rio Vista
7	8		1977	Chinook	Fall	1976	6-CM-74	500	No CWT		3	125	Research - Simpson Lee Corp.
8	15		1977	Chinook	Fall	1976	6-CM-74	300	No CWT		3	100	Research - Simpson Lee Corp.
9	16	30	1977	Chinook	Fall	1976	6-CM-74	600	No CWT		4	60	Research - Simpson Lee Corp.
10	14		1977	Chinook	Fall	1976	6-CM-74	60	No CWT		5	15	Display - Shasta College
11	3	7	1977	Chinook	Fall	1976	6-CM-72	302,373	No CWT		6	17	Red Bluff - Sacramento River
12	11	19	1977	Chinook	Fall	1976	6-CM-72	177,358	No CWT		6-7	13	Battle Creek
12	11	19	1977	Chinook	Fall	1976	6-CM-74	175,695	No CWT		5-6	23	Battle Creek
12	14		1977	Chinook	Fall	1976	6-CM-74	200,124	No CWT		5-6	24	Red Bluff - Sacramento River
12	14	19	1977	Chinook	Fall	1976	6-CM-72	115,318	No CWT		6	14	Red Bluff - Sacramento River
12	16		1977	Chinook	Fall	1977	7-CM-78	983,776	No CWT		ee	ee	Transfer - Feather River SFH

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
1	3	5	1978	Chinook	Fall	1977	7-CM-82	586,993	Partial	[illegible]	5-6	25	Battle Creek
1	8	9	1978	Chinook	Fall	1977	7-CM-82	225,680	Partial	[illegible]	5	23	Red Bluff - Sacramento River
1	24		1978	Chinook	Fall	1976	6-CM-74	251,988	Complete	[illegible]	4-6	23	Battle Creek
1			1978	Chinook	Fall	1977	7-CM-78	25,300	No CWT		2	843	Battle Creek
3			1978	Chinook	Fall	1977	7-CM-78	100,000	No CWT		2	1,000	Battle Creek
4	28		1978	Chinook	Fall	1977	7-UCA-84	284,800	No CWT		3	94	Battle Creek
5	5	26	1978	Chinook	Fall	1977	7-CM-78	1,607,000	No CWT		3	87	Battle Creek
5	11	18	1978	Chinook	Fall	1977	7-UCA-84	1,244,000	No CWT		3	91	Battle Creek
6	1	9	1978	Chinook	Fall	1977	7-CM-78	1,546,000	No CWT		3	94	Battle Creek
6	6	12	1978	Chinook	Fall	1977	7-CM-83	1,425,906	No CWT		3	151	Rio Vista
6	9		1978	Chinook	Fall	1977	7-CM-79	625,000	No CWT		3	90	Battle Creek
6	12		1978	Chinook	Fall	1977	7-CM-82	450	No CWT		2	225	Research - Simpson Lee Corp.
7	17		1978	Chinook	Fall	1977	7-CM-82	800	No CWT		3	133	Research - Simpson Lee Corp.
10	2	24	1978	Chinook	Fall	1977	7-CM-82	941,450	Partial	[illegible]	4	48	Battle Creek
1	9		1979	Chinook	Fall	1977	7-CM-82	30,600	No CWT		6	22	Battle Creek
2	13	14	1979	Chinook	Winter	1978	8-CM-86	9,942	Complete	[illegible]	5	21	Battle Creek
2	14		1979	Chinook	Winter	1978	8-CM-86	308	No CWT		5	21	Tehama Colusa Fish Facilities
2	28		1979	Chinook	Fall	1978	8-UCA-88	400	No CWT		1	1,143	Research - California Dept. Fish and Game
4	13		1979	Chinook	Fall	1978	8-CM-87	500	No CWT		3	125	Tehama Colusa Fish Facilities
4	20	30	1979	Chinook	Fall	1978	8-UCA-88	3,405,975	No CWT		2-3	157	Redding - Sacramento River
4	20	30	1979	Chinook	Fall	1978	8-UCA-88	190,975	No CWT		2-3	186	Battle Creek
4	30		1979	Chinook	Fall	1978	8-CM-87	490,000	No CWT		3	128	Battle Creek
5	9		1979	Chinook	Fall	1978	8-CM-87	42,275	No CWT		3-4	99	Battle Creek
5	16		1979	Chinook	Fall	1978	8-CM-87	500	No CWT		3	83	Tehama Colusa Fish Facilities
6	19		1979	Chinook	Fall	1978	8-CM-87	275	No CWT		4	46	Tehama Colusa Fish Facilities
9	4	7	1979	Chinook	Fall	1978	8-UCA-91	522,575	No CWT		5	23	Red Bluff - Sacramento River
10	19	25	1979	Chinook	Fall	1978	8-CM-87	1,013,482	No CWT		6	17	Battle Creek
12	3		1979	Chinook	Late-Fall	1979	8-CM-90	827,504	No CWT		4-5	36	Battle Creek
2	4		1980	Chinook	Fall	1978	8-CM-87	39,300	No CWT		6	13	Battle Creek
2	4	6	1980	Chinook	Late-Fall	1979	8-CM-90	104,000	Partial	[illegible]	5	25	Battle Creek
2	11		1980	Chinook	Late-Fall	1979	8-CM-90	50,200	Complete	[illegible]	5	24	Red Bluff - Sacramento River
2	20		1980	Chinook	Fall	1979	9-CM-91	51,640	Complete	[illegible], [illegible]	2	420	Berkeley Pier - San Francisco Bay
2	26		1980	Chinook	Fall	1979	9-CM-91	53,893	Complete	[illegible], [illegible]	2	359	Clarksburg - Sacramento River
2	29		1980	Chinook	Fall	1979	9-CM-91	54,410	Complete	[illegible], [illegible]	2	419	Red Bluff - Sacramento River
3	7		1980	Chinook	Fall	1979	9-CM-91	53,518	Complete	[illegible], [illegible]	2	541	Clarksburg - Sacramento River
3	12		1980	Chinook	Fall	1979	9-CM-91	51,284	Complete	[illegible], [illegible]	2	518	Red Bluff - Sacramento River
3	13	15	1980	Chinook	Fall	1979	9-CM-91	180,000	No CWT		2	704	Battle Creek
4	17	28	1980	Chinook	Fall	1979	9-CM-91	3,515,605	No CWT		3	107	Battle Creek
5	7	27	1980	Chinook	Fall	1979	9-CM-91	7,101,883	No CWT		3	127	Battle Creek
6	6	17	1980	Chinook	Late-Fall	1980	9-CM-93	490,263	No CWT		2-3	227	Battle Creek
9	22		1980	Chinook	Late-Fall	1980	9-CM-93	886,591	No CWT		4	62	Battle Creek
9	22		1980	Chinook	Fall	1979	9-CM-91	613,309	No CWT		5-6	21	Battle Creek

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
9	22		1980	Chinook	Fall	1979	9-CM-91	1,600	No CWT		6	20	Research - Red Bluff FAO
12	9		1980	Chinook	Late-Fall	1980	9-CM-93	41,146	No CWT		5	34	Balls Ferry - Sacramento River
2	3		1981	Chinook	Late-Fall	1980	9-CM-93	52,008	Complete	060018	5	25	Battle Creek
2	5		1981	Chinook	Late-Fall	1980	9-CM-93	51,200	Complete	060019	5	24	Red Bluff - Sacramento River
2	6	27	1981	Chinook	Fall	1980	0-CM-96	111,186	Complete	H60101, H60105	2	537	Red Bluff - Sacramento River
2	12		1981	Chinook	Fall	1980	0-CM-96	55,068	Complete	H60102	2	441	Isleton - Sacramento River
2	20		1981	Chinook	Fall	1980	0-CM-96	52,673	Complete	H60103	2	522	Mokelumne River & San Joaquin River
2	25		1981	Chinook	Fall	1980	0-CM-96	57,796	Complete	H60104	2	525	Berkeley Pier - San Francisco Bay
3	4		1981	Chinook	Fall	1980	0-CM-96	51,628	Complete	H60106	2	555	Isleton - Sacramento River
3	6		1981	Chinook	Fall	1980	0-CM-96	50,884	Complete	H60107	2	599	Mokelumne River & San Joaquin River
3	11		1981	Chinook	Fall	1980	0-CM-96	53,175	Complete	H60201	2	604	Berkeley Pier - San Francisco Bay
5	14	29	1981	Chinook	Fall	1980	0-CM-96	13,857,806	Partial	060016	3	110	Battle Creek
5	18		1981	Chinook	Fall	1980	0-CM-96	101,477	Complete	060017	3	82	Red Bluff - Sacramento River
5	18		1981	Chinook	Fall	1980	0-CM-96	102,996	Complete	060020, 060021	3	89	Knights Landing - Sacramento River
11	3		1981	Chinook	Late-Fall	1981	0-CM-97	327,017	No CWT		4	41	Battle Creek
12	2		1981	Chinook	Late-Fall	1981	0-CM-97	1,708,447	No CWT		4.5	38	Battle Creek
1	27		1982	Chinook	Late-Fall	1981	0-CM-97	488,301	Partial	060025	5	34	Battle Creek
1	27		1982	Chinook	Late-Fall	1981	0-CM-97	51,757	Complete	060024	5	35	Red Bluff - Sacramento River
2	5	25	1982	Chinook	Fall	1981	1-CM-99	101,421	Complete	H60202, H60205	2	502	Red Bluff - Sacramento River
2	11		1982	Chinook	Fall	1981	1-CM-99	49,257	Complete	H60203	2	498	Isleton - Sacramento River
2	17		1982	Chinook	Fall	1981	1-CM-99	49,999	Complete	H60204	2	500	San Joaquin River
2	22		1982	Chinook	Fall	1981	1-CM-99	49,876	Complete	H60206	2	499	Berkeley Pier - San Francisco Bay
3	2		1982	Chinook	Fall	1981	1-CM-99	48,982	Complete	H60207	2	500	Isleton - Sacramento River
3	8		1982	Chinook	Fall	1981	1-CM-99	50,671	Complete	H60301	2	502	Berkeley Pier - San Francisco Bay
3	10		1982	Chinook	Fall	1981	1-CM-99	52,163	Complete	H60302	2	502	Mokelumne River & San Joaquin River
3	26		1982	Chinook	Fall	1981	1-CM-99	800	No CWT		2	200	Research - Simpson Lee Corp.
5	5	26	1982	Chinook	Fall	1981	1-CM-99	7,936,225	Partial	060026, 060027	3	96	Battle Creek
5	5		1982	Chinook	Fall	1981	1-CM-99	99,240	Complete	060028, 060029	3	73	Red Bluff - Sacramento River
5	5		1982	Chinook	Fall	1981	1-CM-99	100,652	Complete	060030, 060031	3	77	Knights Landing - Sacramento River
5	12		1982	Chinook	Fall	1981	1-CM-99	101,676	Complete	060218	3	78	Discovery Park - Sacramento River
5	17		1982	Chinook	Fall	1981	1-CM-99	98,501	Complete	060219	3	71	Port Chicago
5	26		1982	Chinook	Fall	1981	1-CM-99	1,000	No CWT		3	250	Research - Simpson Lee Corp.
6	2		1982	Chinook	Fall	1981	1-CM-99	250,000	No CWT		3	173	Battle Creek
8	2		1982	Chinook	Late-Fall	1982	2-CM-02	350	No CWT		3	175	Research - Simpson Lee Corp.
10	1		1982	Chinook	Late-Fall	1982	2-CM-02	777,516	No CWT		4	36	Battle Creek
12	1		1982	Chinook	Fall	1982	2-CM-04	799,200	No CWT		ee	ee	Tehama Colusa Fish Facilities
12	28		1982	Chinook	Fall	1982	2-CM-04	219,040	No CWT		2	1,360	Antelope Creek
1	3		1983	Chinook	Late-Fall	1982	2-CM-02	909,308	No CWT		4.5	40	Battle Creek
1	17		1983	Chinook	Fall	1982	2-CM-04	538,720	No CWT		1.5	1,189	Tehama Colusa Fish Facilities
1	18	25	1983	Chinook	Fall	1982	2-CM-04	805,420	No CWT		1.5	1,239	Antelope Creek
1	18	27	1983	Chinook	Fall	1982	2-CM-04	2,101,920	No CWT		1.5	1,201	Posse Grounds - Sacramento River
2	4	18	1983	Chinook	Fall	1982	2-CM-04	1,136,090	No CWT		1.5	1,190	Battle Creek

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
2	23		1983	Chinook	Fall	1982	2-CM-04	545,720	No CWT		1.5	1,111	Posse Grounds - Sacramento River
3	17		1983	Chinook	Winter	1982	2-CM-03	11,548	Complete	[illegible]	4.5	39	Battle Creek
4	1	29	1983	Chinook	Fall	1982	2-CM-04	950	No CWT		3	190	Research - Simpson Lee Corp.
4	28	29	1983	Chinook	Fall	1982	2-CM-04	3,114,000	No CWT		3	89	Battle Creek
5	3		1983	Chinook	Fall	1982	2-CM-04	200	No CWT		3	200	Display - NEED Camp, Clear Creek
5	4	27	1983	Chinook	Fall	1982	2-CM-04	3,671,312	No CWT		3	94	Battle Creek
5	13		1983	Chinook	Fall	1982	2-CM-04	500	No CWT		3	125	Research - UC Davis
5	13	26	1983	Chinook	Fall	1982	2-CM-04	600	No CWT		3	150	Research - Simpson Lee Corp.
5	24	27	1983	Chinook	Fall	1982	2-CM-04	1,173,350	No CWT		3	103	Red Bluff - Sacramento River
6	1	9	1983	Chinook	Fall	1982	2-CM-04	1,258,400	Partial	[illegible]	3	109	Red Bluff - Sacramento River
6	1	9	1983	Chinook	Fall	1982	2-CM-04	2,448,595	Partial	[illegible]	3	104	Battle Creek
6	2		1983	Chinook	Fall	1982	2-CM-04	99,938	Complete	[illegible]	3	98	Knights Landing - Sacramento River
6	2		1983	Chinook	Late-Fall	1983	2-CM-06	400	No CWT		1	400	Tehama Colusa Fish Facilities
6	8		1983	Chinook	Fall	1982	2-CM-04	300	No CWT		3	100	Research - UC Davis
6	8		1983	Chinook	Fall	1982	2-CM-04	21,000	No CWT		3	97	Transfer - CDFG, Redding CA
6	9		1983	Chinook	Fall	1982	2-CM-04	100	No CWT		3	100	Research - FAO Red Bluff
6	10	24	1983	Chinook	Fall	1982	2-CM-04	700	No CWT		3	175	Research - Simpson Lee Corp.
9	15	22	1983	Chinook	Fall	1982	2-CM-04	441,178	No CWT		5	32	Battle Creek
11	16		1983	Chinook	Late-Fall	1983	2-CM-06	100	No CWT		4-4.5	50	Research - UC Davis
11	17	21	1983	Chinook	Late-Fall	1983	2-CM-06	287,475	No CWT		4.5	37	Red Bluff - Sacramento River
11	22		1983	Chinook	Late-Fall	1983	2-CM-06	13,542	No CWT		4.5	36	Battle Creek
1	12	17	1984	Chinook	Late-Fall	1983	2-CM-06	406,267	No CWT		4-5	33	Battle Creek
1	17	19	1984	Chinook	Late-Fall	1983	2-CM-06	651,083	No CWT		4-4.5	38	Red Bluff - Sacramento River
3	1	23	1984	Chinook	Fall	1983	3-CM-08	102,740	Complete	[illegible]	2	447	Red Bluff - Sacramento River
3	2		1984	Chinook	Fall	1983	3-CM-08	3,000	No CWT		2	429	Research - FAO Red Bluff
3	5	21	1984	Chinook	Fall	1983	3-CM-08	101,866	Complete	[illegible]	2	445	Courtland - Sacramento River
3	8	19	1984	Chinook	Fall	1983	3-CM-08	101,241	Complete	[illegible]	2	444	Walnut Grove - Sacramento River
3	12		1984	Chinook	Fall	1983	3-CM-08	50,679	Complete	[illegible]	2	452	North Fork Mokelumne River
3	14		1984	Chinook	Fall	1983	3-CM-08	51,765	Complete	[illegible]	2	454	S. Fork, Mokelumne River
4	13		1984	Chinook	Fall	1983	3-CM-08	300	No CWT		2	300	Research - Simpson Lee Corp.
4	23		1984	Chinook	Fall	1983	3-CM-08	1,787,312	No CWT		3.5	76	Battle Creek
4	26		1984	Chinook	Fall	1983	3-CM-08	300,000	No CWT		3	102	Red Bluff - Sacramento River
5	3	14	1984	Chinook	Fall	1983	3-CM-08	3,606,923	Partial	[illegible]	3-4	113	Battle Creek
5	3		1984	Chinook	Fall	1983	3-UCA-09	564,450	No CWT		3.5	84	Red Bluff - Sacramento River
5	9		1984	Chinook	Fall	1983	3-CM-08	100,766	Complete	[illegible]	4	56	Knights Landing - Sacramento River
5	9	17	1984	Chinook	Fall	1983	3-CM-08	3,199,490	Partial	[illegible]	3	109	Red Bluff - Sacramento River
5	17		1984	Chinook	Late-Fall	1984	3-CM-12	250	No CWT		2.5	250	Research - Simpson Lee Corp.
6	4	29	1984	Chinook	Fall	1983	3-CM-08	23,921	No CWT		3-3.5	95	Research - FAO Red Bluff
6	8		1984	Chinook	Late-Fall	1984	3-CM-12	250	No CWT		2	250	Research - Simpson Lee Corp.
7	5	10	1984	Chinook	Fall	1983	3-CM-08	7,460	No CWT		3.5-4	75	Research - FAO Red Bluff
7	10		1984	Chinook	Fall	1983	3-CM-08	19,480	No CWT		4	4	Battle Creek
10	18		1984	Chinook	Fall	1984	4-CM-13	8,000	No CWT		ee	ee	Research - Diamond International Corp.

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	Distribution Date										Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
11	20		1984	Chinook	Late-Fall	1984	3-CM-12	88,900	No CWT		5	26	Battle Creek
11	20		1984	Chinook	Late-Fall	1984	3-CM-12	154,575	No CWT			35	Red Bluff - Sacramento River
1	7		1985	Chinook	Fall	1984	4-CM-13	700	No CWT		2	117	Research - Simpson Lee Corp.
1	8		1985	Chinook	Late-Fall	1984	3-CM-12	65,992	No CWT		4	49	Battle Creek
1	8		1985	Chinook	Fall	1984	4-CM-13	2,400	No CWT		1.5	800	Research - FAO Red Bluff
1	10		1985	Chinook	Late-Fall	1984	3-CM-12	65,380	No CWT		4	47	Red Bluff - Sacramento River
1	24	31	1985	Chinook	Fall	1984	4-CM-13	4,141,440	No CWT		1.5	1,280	Posse Grounds - Sacramento River
1	25	29	1985	Chinook	Fall	1984	4-CM-13	656,640	No CWT		1.5	1,283	Balls Ferry - Sacramento River
1	25	31	1985	Chinook	Fall	1984	4-CM-13	2,937,600	No CWT		1.5	1,278	North Street Bridge - Sacramento River
1	25		1985	Chinook	Fall	1984	4-CM-13	169,040	No CWT		1.5	801	Battle Creek
2	1	4	1985	Chinook	Fall	1984	4-CM-13	656,640	No CWT		1.5	1,293	Lake Redding Park - Sacramento River
2	1	5	1985	Chinook	Fall	1984	4-CM-13	1,546,560	No CWT		1.5	1,308	North Street Bridge - Sacramento River
2	1	5	1985	Chinook	Fall	1984	4-CM-13	1,211,040	No CWT		1.5	1,302	Balls Ferry - Sacramento River
2	4	5	1985	Chinook	Fall	1984	4-CM-13	665,280	No CWT		1.5	1,315	Posse Grounds - Sacramento River
2	13		1985	Chinook	Fall	1984	4-CM-13	250	No CWT		2.5	3	Research - Simpson Lee Corp.
2	14		1985	Chinook	Fall	1984	4-CM-13	56,500	Complete	[illegible]	2	401	Red Bluff - Sacramento River
2	19		1985	Chinook	Fall	1984	4-CM-13	57,400	Complete	[illegible]	2	361	Courtland - Sacramento River
2	21		1985	Chinook	Fall	1984	4-CM-13	55,700	Complete	H60007	2	404	Koket - Sacramento River
2	26		1985	Chinook	Fall	1984	4-CM-13	52,850	Complete	H60001	2.5	370	S. Fork, Mokelumne River
2	28		1985	Chinook	Fall	1984	4-CM-13	53,000	Complete	H60002	2	421	North Fork Mokelumne River
3	5		1985	Chinook	Fall	1984	4-CM-13	54,900	Complete	[illegible]	2	389	Koket - Sacramento River
3	7		1985	Chinook	Fall	1984	4-CM-13	53,100	Complete	[illegible]	2	382	Courtland - Sacramento River
3	8		1985	Chinook	Fall	1984	4-CM-13	199,280	No CWT		2.5	376	Clear Creek
3	11		1985	Chinook	Fall	1984	4-CM-13	201,770	No CWT		2.5	376	Antelope Creek
3	12		1985	Chinook	Fall	1984	4-CM-13	204,660	No CWT		2.5	376	Cow Creek
3	12	13	1985	Chinook	Fall	1984	4-CM-13	57,060	Partial	[illegible]	2.5	363	Battle Creek
3	14		1985	Chinook	Fall	1984	4-CM-13	53,600	Complete	[illegible]	2.5	362	Red Bluff - Sacramento River
3	15		1985	Chinook	Fall	1984	4-CM-13	6,450	No CWT		1.5	1,290	Research - FAO Red Bluff
3	29		1985	Chinook	Fall	1984	4-CM-13	250	No CWT		2.5	250	Research - Simpson Lee Corp.
4	3	22	1985	Chinook	Fall	1984	4-CM-13	1,458,082	No CWT		3-4	91	Battle Creek
4	17		1985	Chinook	Fall	1984	4-CM-13	5,145	No CWT		3	147	Research - FAO Red Bluff
4	18	22	1985	Chinook	Fall	1984	4-CM-13	2,007,000	No CWT		3.5	73	Red Bluff - Sacramento River
4	19		1985	Chinook	Fall	1984	4-CM-13	250	No CWT		2.5	250	Research - Simpson Lee Corp.
5	7	15	1985	Chinook	Fall	1984	4-CM-13	13,000	No CWT		3	125	Research - FAO Red Bluff
5	10		1985	Chinook	Fall	1984	4-CM-13	250	No CWT		3	250	Research - Simpson Lee Corp.
5	13		1985	Chinook	Fall	1984	4-CM-13	500	No CWT		3.5	83	Research - UC Davis
5	14	15	1985	Chinook	Fall	1984	4-CM-13	4,320,341	Partial	[illegible]	3-4	83	Battle Creek
5	14	15	1985	Chinook	Fall	1984	4-CM-13	2,482,237	Partial	[illegible]	3-4	98	Red Bluff - Sacramento River
5	15		1985	Chinook	Fall	1984	4-CM-13	66,790	Complete	[illegible]	4	59	Princeton - Sacramento River
6	5	28	1985	Chinook	Fall	1984	4-CM-13	27,100	No CWT		3.5	100	FAO Red Bluff

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

	Distribution Date										Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
6	13		1985	Chinook	Fall	1984	4-CM-13	610,227	Partial	060960, 060961	3.5	97	Tehama Colusa Fish Facilities
6	13		1985	Chinook	Fall	1984	4-CM-13	5,820	No CWT		3.5	97	Battle Creek
7	5		1985	Chinook	Fall	1984	4-CM-13	21,280	No CWT		3.5	80	FAO Red Bluff
10	16		1985	Chinook	Late-Fall	1985	5-CM-15	100	No CWT			50	Research - California Dept. Fish and Game
10	17		1985	Chinook	Fall	1985	5-CM-16	10,000	No CWT		ee	ee	Research - Diamond International Corp.
11	23		1985	Chinook	Fall	1984	4-CM-13	729,600	No CWT		ee	ee	Tehama Colusa Fish Facilities
12	6		1985	Chinook	Late-Fall	1985	5-CM-15	210,408	No CWT			24	Battle Creek
12	9		1985	Chinook	Late-Fall	1985	5-CM-15	103,704	No CWT			28	Red Bluff - Sacramento River
1	29		1986	Chinook	Fall	1985	5-CM-16	800	No CWT			400	Research - California Dept. Fish and Game
2	12		1986	Chinook	Fall	1985	5-CM-16	100	No CWT			100	Research - California Dept. Fish and Game
2	27		1986	Chinook	Fall	1985	5-CM-16	53,000	Complete	H60807		445	Courtland - Sacramento River
3	4	12	1986	Chinook	Fall	1985	5-CM-16	108,056	Complete	H60702, H60704		343	Koket - Sacramento River
3	7	25	1986	Chinook	Fall	1985	5-CM-16	550	No CWT			275	Research - Simpson Lee Corp.
3	10		1986	Chinook	Fall	1985	5-CM-16	55,345	Complete	H60703		337	Courtland - Sacramento River
3	18	31	1986	Chinook	Fall	1985	5-CM-16	581,210	Partial	H60707		341	Battle Creek
3	19		1986	Chinook	Fall	1985	5-CM-16	1,583,676	Partial	H60706		330	Red Bluff - Sacramento River
3	31		1986	Chinook	Fall	1985	5-CM-16	20,000	No CWT			333	FAO Red Bluff
4	4	21	1986	Chinook	Fall	1985	5-CM-16	2,044,279	No CWT			250	Battle Creek
4	14		1986	Chinook	Fall	1985	5-CM-16	608,140	No CWT			159	Red Bluff - Sacramento River
4	17		1986	Chinook	Fall	1985	5-CM-16	350	No CWT			117	Research - Simpson Lee Corp.
5	1	23	1986	Chinook	Fall	1985	5-CM-16	500	No CWT			125	Research - Simpson Lee Corp.
5	9	13	1986	Chinook	Fall	1985	5-CM-16	3,419,026	Partial	H60404, H60405		106	Red Bluff - Sacramento River
5	12	27	1986	Chinook	Fall	1985	5-CM-16	5,800,066	Partial	H60402, H60403		90	Battle Creek
5	13		1986	Chinook	Fall	1985	5-CM-16	46,537	Complete	H60406, H60407		64	Princeton - Sacramento River
5	21		1986	Chinook	Fall	1985	5-CM-16	10,027	No CWT			98	FAO Red Bluff
5	27		1986	Chinook	Fall	1985	5-CM-16	603,000	No CWT			90	Tehama Colusa Fish Facilities
6	2	10	1986	Chinook	Fall	1985	5-CM-16	69,863	No CWT			65	FAO Red Bluff
11	4		1986	Chinook	Late-Fall	1986	6-CM-18	317,988	No CWT			29	Red Bluff - Sacramento River
11	12		1986	Chinook	Late-Fall	1986	6-CM-18	392,012	No CWT			28	Battle Creek
2	4	20	1987	Chinook	Fall	1986	6-CM-19	1,494,700	No CWT			374	Battle Creek
3	5		1987	Chinook	Fall	1986	6-CM-19	51,789	Complete	60706		339	Courtland - Sacramento River
3	12	27	1987	Chinook	Fall	1986	6-CM-19	403,869	Partial	B60413		203	Battle Creek
3	13		1987	Chinook	Fall	1986	6-CM-19	54,280	Complete	H60707		310	Red Bluff - Sacramento River
4	20		1987	Chinook	Fall	1986	6-CM-19	5,312,900	No CWT			100	Battle Creek
4	20		1987	Chinook	Fall	1986	6-CM-19	1,051,309	Partial	B60306		103	Tehama Colusa Fish Facilities
4	24	28	1987	Chinook	Fall	1986	6-CM-19	27,700	No CWT			73	FAO Red Bluff
5	1		1987	Chinook	Fall	1986	6-CM-19	200	No CWT			200	Research - Simpson Lee Corp.
5	3	13	1987	Chinook	Fall	1986	6-CM-19	269,365	Partial	061840		68	Red Bluff - Sacramento River
5	12		1987	Chinook	Fall	1986	6-CM-19	4,124,174	Partial	061838		77	Battle Creek
5	13		1987	Chinook	Fall	1986	6-CM-19	18,100	No CWT			[illegible]	FAO Red Bluff
5	14		1987	Chinook	Fall	1986	6-CM-19	51,561	Complete	061841		68	Princeton - Sacramento River
6	5		1987	Chinook	Fall	1986	6-CM-19	11,800	No CWT			60	Battle Creek

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
7	22		1987	Chinook	Late-Fall	1987	7-CM-22	110	No CWT			55	Research - Humboldt State University
10	27		1987	Chinook	Fall	1987	7-CM-23	15,000	No CWT		ee	ee	Research - Diamond International Corp.
11	20		1987	Chinook	Late-Fall	1987	7-CM-21	629,100	No CWT			24	Battle Creek
11	20		1987	Chinook	Late-Fall	1987	7-CM-22	435,600	No CWT			25	Battle Creek
12	22		1987	Chinook	Fall	1987	7-CM-23	507,000	No CWT			1,213	Battle Creek
1	4	22	1988	Chinook	Fall	1987	7-CM-23	4,500,719	No CWT			1,211	North Street Bridge - Sacramento River
2	16	24	1988	Chinook	Fall	1987	7-CM-23	950,666	No CWT			728	North Street Bridge - Sacramento River
2	19		1988	Chinook	Fall	1987	7-CM-23	55,325	Complete	060206		457	Battle Creek
2	22		1988	Chinook	Fall	1987	7-CM-23	54,247	Complete	061401		350	Red Bluff - Sacramento River
2	22		1988	Chinook	Fall	1987	7-CM-23	250	No CWT			250	Research - Simpson Lee Corp.
3	11	25	1988	Chinook	Fall	1987	7-CM-23	600	No CWT			300	Research - Simpson Lee Corp.
4	1	15	1988	Chinook	Fall	1987	7-CM-23	725,187	No CWT			103	Red Bluff - Sacramento River
4	5	12	1988	Chinook	Fall	1987	7-CM-23	1,157,100	No CWT			159	Tehama Colusa Fish Facilities
4	11	19	1988	Chinook	Fall	1987	7-CM-23	514,910	No CWT			114	Battle Creek
4	15		1988	Chinook	Fall	1987	7-CM-23	350	No CWT			350	Research - Simpson Lee Corp.
5	6		1988	Chinook	Fall	1987	7-CM-23	250	No CWT			250	Research - Simpson Lee Corp.
5	9	13	1988	Chinook	Fall	1987	7-CM-23	4,573,025	Partial	051940		75	Red Bluff - Sacramento River
5	9	13	1988	Chinook	Fall	1987	7-CM-23	6,155,967	Partial	051939		84	Battle Creek
5	11		1988	Chinook	Fall	1987	7-CM-23	53,036	Complete	051941		67	Princeton - Sacramento River
5	17		1988	Chinook	Fall	1987	7-CM-23	52,921	Complete	051942		60	Benicia
12	8		1988	Chinook	Late-Fall	1988	8-CM-25	510,890	No CWT			22	Battle Creek
12	8		1988	Chinook	Late-Fall	1988	8-CM-26	24,510	No CWT			11	Battle Creek
1	12		1989	Chinook	Late-Fall	1988	8-CM-25	100	No CWT			25	FAO Red Bluff
1	19		1989	Chinook	Late-Fall	1988	8-CM-25	126,679	No CWT			20	Battle Creek
2	3	24	1989	Chinook	Fall	1988	8-CM-27	5,678,534	No CWT			610	Red Bluff - Sacramento River
2	16		1989	Chinook	Fall	1988	8-CM-27	200,000	No CWT			500	Stillwater Creek
2	16		1989	Chinook	Fall	1988	8-CM-27	100,500	No CWT			500	Anderson Creek
3	6	23	1989	Chinook	Fall	1988	8-CM-27	3,824,520	No CWT			627	Balls Ferry - Sacramento River
3	23		1989	Chinook	Fall	1988	8-CM-27	684,193	No CWT			635	Red Bluff - Sacramento River
3	28		1989	Chinook	Fall	1988	8-CM-27	53,950	No CWT			650	Battle Creek
4	12		1989	Chinook	Fall	1988	8-CM-89	250	No CWT			250	Research - Simpson Lee Corp.
5	3		1989	Chinook	Fall	1988	8-CM-27	250	No CWT			250	Research - Simpson Lee Corp.
5	8		1989	Chinook	Fall	1988	8-CM-27	6,001,147	Partial	[illegible]		136	Battle Creek
5	9	10	1989	Chinook	Fall	1988	8-CM-27	5,537,520	Partial	[illegible]		118	Red Bluff - Sacramento River
5	10		1989	Chinook	Fall	1988	8-CM-27	51,356	Complete	[illegible]		111	Princeton - Sacramento River
5	15		1989	Chinook	Fall	1988	8-CM-27	40,934	Complete	[illegible]		107	Benicia
12	19		1989	Chinook	Late-Fall	1989	KEW-89-COL	118,117	No CWT		5	23	Battle Creek
1	5	89	1990	Chinook	Late-Fall	1989	KEW-89-COL	277,183	No CWT		5	25	Sacramento River
1	8		1990	Chinook	Late-Fall	1989	BCW-89-COL	61,105	No CWT				Battle Creek
1	8	26	1990	Chinook	Late-Fall	1989	KEW-89-COL	452,341	Partial	[illegible]	5.5	20	Battle Creek
1	25		1990	Chinook	Winter	1989	9-CM-32	3,203	No CWT		3.7	68	Sacramento River
2	26		1990	Chinook	Late-Fall	1990	BCW-90-COL	568	No CWT		ee	ee	Research - FAO Red Bluff

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
2	26		1990	Chinook	Late-Fall	1990	KEW-90-COL	2,749	No CWT		ee	ee	Research - FAO Red Bluff
3	5	23	1990	Chinook	Fall	1989	BCW-89-COL	3,919,302	No CWT		2	453	Sacramento River
3	30		1990	Chinook	Fall	1989	BCW-89-COL	769,343	No CWT		2	400	Battle Creek
4	27		1990	Chinook	Fall	1989	BCW-89-COL	9,000	No CWT		3	118	Research - Glenn-Colusa Irrigation District
5	2	10	1990	Chinook	Fall	1989	BCW-89-COL	19,000	No CWT		3	229	Research - Glenn-Colusa Irrigation District
5	4	14	1990	Chinook	Fall	1989	BCW-89-COL	6,313,300	Partial	062067	3.5	74	Princeton - Sacramento River
5	10	11	1990	Chinook	Fall	1989	BCW-89-COL	154,643	Partial	[illegible]			Battle Creek
5	12		1990	Chinook	Fall	1989	BCW-89-COL	52,212	Complete	[illegible]	3.5	73	Red Bluff - Sacramento River
5	13	22	1990	Chinook	Fall	1989	BCW-89-COL	5,661,126	Partial	[illegible]	3.5	88	Benicia
10	30		1990	Chinook	Fall	1990	BCW-90-COL	719,188	No CWT		ee	ee	Transfer - Feather River SFH
11	1		1990	Chinook	Fall	1990	BCW-90-COL	540,750	No CWT		ee	ee	Transfer - Feather River SFH
1	15		1991	Chinook	Winter	1990	SRW-90-COL	1,286	No CWT		3.5	76	Caldwell Park - Sacramento River
1	16	31	1991	Chinook	Late-Fall	1990	BCW-90-COL	129,351	No CWT		6-6.5	13	Battle Creek
1	16	31	1991	Chinook	Late-Fall	1990	KEW-90-COL	74,036	No CWT		6	15	Battle Creek
2	15		1991	Chinook	Fall	1990	BCW-90-COL	369	No CWT		2		Research - Simpson Lee Corp.
2	26		1991	Chinook	Fall	1990	BCW-90-COL	100,194	No CWT		2	370	North Fork Battle Creek
2	26		1991	Chinook	Fall	1990	BCW-90-COL	99,824	No CWT		2	370	South Fork Battle Creek
2	28		1991	Chinook	Fall	1990	BCW-90-COL	271,156	No CWT		2	339	Anderson Cottonwood Irrigation District Dam - Sacramento River
2	28		1991	Chinook	Fall	1990	BCW-90-COL	550,045	No CWT		2	341	Anderson River Park - Sacramento River
2	28		1991	Chinook	Fall	1990	BCW-90-COL	672,569	No CWT		2	385	Balls Ferry - Sacramento River
2	28		1991	Chinook	Fall	1990	BCW-90-COL	307,619	No CWT		2	374	Bend Bridge - Sacramento River
2	28		1991	Chinook	Fall	1990	BCW-90-COL	680,214	No CWT		2	405	Sacramento River @ Battle Creek
2	28		1991	Chinook	Fall	1990	BCW-90-COL	324,679	No CWT		2	402	Posse Grounds - Sacramento River
3	1	25	1991	Chinook	Fall	1990	BCW-90-COL	4,518,601	Partial	0601010111	2	550	Red Bluff - Sacramento River
3	1		1991	Chinook	Fall	1990	BCW-90-COL	666,834	No CWT		2	420	Woodson Bridge - Sacramento River
4	8		1991	Chinook	Fall	1990	BCW-90-COL	400	No CWT		2		Research - Simpson Lee Corp.
3	4	11	1991	Chinook	Fall	1990	BCW-90-COL	2,442,869	Partial	0601010110	2	473	Battle Creek
4	15		1991	Chinook	Fall	1990	BCW-90-COL	21,000	No CWT		2		Research - Glenn-Colusa Irrigation District
4	22	29	1991	Chinook	Fall	1990	BCW-90-COL	6,349,775	No CWT		2	93	Princeton - Sacramento River
4	23	26	1991	Chinook	Fall	1990	BCW-90-COL	19,656	No CWT		2.5	234	Research - Glenn-Colusa Irrigation District
4	29	30	1991	Chinook	Fall	1990	BCW-90-COL	901,820	No CWT		2	149	Benicia
4	30		1991	Chinook	Fall	1990	BCW-90-COL	64,698	Complete	0601010113	2	86	Battle Creek
5	1		1991	Chinook	Fall	1990	BCW-90-COL	64,700	Complete	0601010112	2	91	Red Bluff - Sacramento River
5	1	13	1991	Chinook	Fall	1990	BCW-90-COL	5,098,734	Partial	0601010104	3-3.5	111	Benicia
5	3	6	1991	Chinook	Fall	1990	BCW-90-COL	273,150	Partial	061846, 061847, 061848	2	156	Princeton - Sacramento River
5	3		1991	Chinook	Fall	1990	BCW-90-COL	295	No CWT		3	98	Research - Simpson Lee Corp.
5	7		1991	Chinook	Fall	1990	BCW-90-COL	13,675	No CWT		3	149	Research - Glenn-Colusa Irrigation District
7	23		1991	Chinook	Late-Fall	1991	BCW-91-COL	1,189	No CWT		2	297	Transfer - Red Bluff FRO
1	3	6	1992	Chinook	Late-Fall	1991	LFS-91-COL	302,962	Partial	[illegible]	6.5	13	Battle Creek

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
1	21		1992	Chinook	Winter	1991	SRW-91-COL	11,582	Complete	0601010403, 0601010404, 0601010405, 0601010406	3.5	60	Caldwell Park - Sacramento River
9	16		1992	Chinook	Winter	1991	SRW-91-COL	746			6.9		Bodega Bay Marine Lab - Captive Broodstock Program
2	13	28	1992	Chinook	Fall	1991	BCW-91-COL	4,761,200	No CWT		2	452	Red Bluff - Sacramento River
2	25		1992	Chinook	Fall	1991	BCW-91-COL	25,369	Complete	0601110206	2	518	Verona
3	3	19	1992	Chinook	Fall	1991	BCW-91-COL	6,318,720	Partial	0601010310, 050503	2	406	Red Bluff - Sacramento River
3	3	10	1992	Chinook	Fall	1991	BCW-91-COL	53,143	Complete	0601110207, 0601110208	2	436	Verona
3	16		1992	Chinook	Fall	1991	BCW-91-COL	24,350	Complete	0601110209	2	343	Miller Park - Sacramento River
3	23		1992	Chinook	Fall	1991	BCW-91-COL	10,234	No CWT		2	445	Battle Creek
4	6	21	1992	Chinook	Fall	1991	BCW-91-COL	13,839,767	Partial	062819	3	133	Princeton - Sacramento River
4	14	21	1992	Chinook	Fall	1991	BCW-91-COL	200,317	Partial	062812, 062813, 062814	3	111	Battle Creek
4	15		1992	Chinook	Fall	1991	BCW-91-COL	54,556	Complete	062816	3	113	Red Bluff - Sacramento River
4	28		1992	Chinook	Fall	1991	BCW-91-COL	54,878	Complete	052830	3.5	80	Benicia
11	19		1992	Chinook	Late-Fall	1992	B&K-92-COL	100	Complete	063120	5	20	Research - NCVFRO, Red Bluff
11	20		1992	Chinook	Late-Fall	1992	B&K-92-COL	15,002	Complete	063120	5	22	Research - SSJFRO-Clifton Ct. Forebay
1	4		1993	Chinook	Late-Fall	1992	B&K-92-COL	325,244	Complete	[illegible], [illegible], 063122, 063121	5.5	14	Battle Creek
1	27		1993	Chinook	Winter	1992	SRW-92-COL	26,433	Complete	0601010609, 0601010610, 0601010611, 0601010614, 0601010612, 0601010713, 0601010613, 0601010714, 0601010607, 0601010616, 0601010701, 0601010702, 0601010608, 0601010712, 0601010705, 0601010709, 0601010704, 0601010706, 0601010703, 0601010716, 0601010707, 0601010708	3	74	North Street Bridge - Sacramento River

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Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
2	17	18	1993	Chinook	Winter	1992	SRW-92-COL	971	Complete	[illegible], 0601010810, [illegible], 0601010701, [illegible], 0601010707, [illegible], 0601010704, [illegible], 0601010703, 0601010710, 0601010702, [illegible], 0601010712, [illegible], 0601010811, 0601010814, 0601010812, 0601010713, 0601010813, 0601010714, 0601010807	3	74	Bodega Bay Marine Lab. - Captive Broodstock Program
2	23		1993	Chinook	Fall	1992	BCW-92-COL	5,750	No CWT		1-1.5	1,150	Research - UC Davis
3	10		1993	Chinook	Fall	1992	BCW-92-COL	123,743	Complete	0601010801, 0601010802	2	273	Red Bluff - Sacramento River
3	23	30	1993	Chinook	Fall	1992	BCW-92-COL	3,460,081	No CWT		2.5	172	Battle Creek
4	6		1993	Chinook	Fall	1992	BCW-92-COL	250	No CWT		2	250	Research - Glenn-Colusa Irrigation District
4	13	26	1993	Chinook	Fall	1992	BCW-92-COL	8,354,884	Partial	0601010803, [illegible], 0601010804, 0601141101, 0601141102	3	109	Battle Creek
5	14		1993	Chinook	Fall	1992	BCW-92-COL	10,580	No CWT		3.5-4	46	Research - NCVFRO, Red Bluff
11	18		1993	Chinook	Late-Fall	1993	B&K-93-COL	15,577	Complete	053417	5	19	Research - CDFG, Byron, CA
12	2		1993	Chinook	Late-Fall	1993	B&K-93-COL	33,868	Complete	[illegible]	5	22	Georgiana Slough
12	2		1993	Chinook	Late-Fall	1993	B&K-93-COL	34,929	Complete	[illegible]	5	19	Research - SSJFRO- Ryde-Kokel
12	28		1993	Chinook	Late-Fall	1993	B&K-93-COL	238	Complete	[illegible], [illegible]	5	14	Research- Nimbus SFH
1	3	5	1994	Chinook	Late-Fall	1993	B&K-93-COL	676,131	Complete	[illegible], [illegible], 053411, [illegible], [illegible], 053412, 053413, 053414, 053415, [illegible]	5.5	14	Battle Creek
1	27		1994	Chinook	Winter	1993	SRW-93-COL	18,723	Complete	[illegible], 0601010911, [illegible], [illegible], [illegible], [illegible], [illegible], [illegible], [illegible], [illegible], [illegible], [illegible]	3	70	Caldwell Park - Sacramento River
2	7	16	1994	Chinook	Fall	1993	BCW-93-COL	2,226,597	No CWT		1.5-2	579	Red Bluff - Sacramento River

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Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
2	28		1994	Chinook	Winter	1993	SRW-93-COL	998	Complete	0501010810, 0501010811, 0501010812, 0501010806, 0501010807, 0501010814, 0501010815, 0501010805, 0501010801, 0501010802, 0501010803, 0501010813	4	37	Caldwell Park - Sacramento River
3	1	10	1994	Chinook	Fall	1993	BCW-93-COL	2,287,347	Partial	0501010808, 0501010809	1.5-2	451	Red Bluff - Sacramento River
3	10		1994	Chinook	Fall	1993	BCW-93-COL	34,775	No CWT		2	419	Battle Creek
3	28		1994	Chinook	Fall	1993	BCW-93-COL	2,557	No CWT		2	8	Research - NBS, Columbia, MO.
4	14	15	1994	Chinook	Fall	1993	BCW-93-COL	12,129,576	Partial	063427, 063428, 063429	2-3	103	Battle Creek

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
5	9		1994	Chinook	Fall	1993	BCW-93-COL	21,940	No CWT		3	94	Research - NCVFRO, Red Bluff
11	10		1994	Chinook	Late-Fall	1994	B&K-94-COL	64,919	Complete	053822			Battle Creek
11	20		1994	Chinook	Late-Fall		B&K-95-COL	2,073	No CWT		5.5	17	Research - CDFG, Byron, CA
12	5		1994	Chinook	Late-Fall	1994	B&K-94-COL	32,176	Complete	053435	4.5-5	23	Georgiana Slough
12	5		1994	Chinook	Late-Fall	1994	B&K-94-COL	30,525	Complete	053436	4.5-5	23	Walnut Grove - Sacramento River
12	7		1994	Chinook	Late-Fall	1994	B&K-94-COL	63,629	Complete	053742			
1	26		1995	Chinook	Winter	1994	SRW-94-COL	43,346	Complete	0601011103, 0601011104, 0601011106, 0601011105, 0601011107, 0601011108, 0601011109, 0601011110, 0601011111, 0601011112, 0601011113, 0601011114, 0601011115, 0601011201, 0601011202, 0601011203, 0601011002, 0601011003, 0601011004, 0601011005, 0601011006, 0601011007, 0601011008, 0601011009, 0601011010, 0601011011, 0601011012, 0601011013, 0601011014, 0601011015, 0601011101, 0601011102	3	74	Bonneyview Boat Ramp- Sacramento River
3	16		1995	Chinook	Winter	1994	SRW-94-COL	330	Complete	0601011103, 0601011104, 0601011106, 0601011105, 0601011108, 0601011112, 0601011113, 0601011114, 0601011115, 0601011201, 0601011202, 0601011203, 0601011013, 0601011014, 0601011101, 0601011102	4	37	Steinhart Aquarium - Captive Broodstock Program

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
5	10		1995	Chinook	Winter	1994	SRW-94-COL	333	Complete	0501011107, 0501011108, 0501011110, 0501011111, 0501011002, 0501011003, 0501011004, 0501011005, 0501011006, 0501011007, 0501011008, 0501011009, 0501011010, 0501011011, 0501011012, 0501011015	4.5	27	Steinhart Aquarium - Captive Broodstock Program
1	4	11	1995	Chinook	Late-Fall	1994	B&K-94-COL	378,098	Complete	[illegible], [illegible], 062821, 063743	5.5-6	14	Battle Creek
1	4		1995	Chinook	Late-Fall	1994	B&K-94-COL	31,644	Complete	[illegible]	5.5	15	Georgiana Slough
1	5		1995	Chinook	Late-Fall	1994	B&K-94-COL	31,676	Complete	[illegible]	5.5-6	13	SSJFRO
2	13	23	1995	Chinook	Fall	1994	BCW-94-COL	1,482,415	No CWT		2.0	410	Red Bluff - Sacramento River
3	10		1995	Chinook	Fall	1994	BCW-94-COL	101,331	Complete	05111205, 05111204	2	349	Red Bluff - Sacramento River
3	14	23	1995	Chinook	Fall	1994	BCW-94-COL	1,317,557	No CWT		2	418	Balls Ferry - Sacramento River
3	23	29	1995	Chinook	Fall	1994	BCW-94-COL	1,141,830	No CWT		2-2.5	205	Battle Creek
3	24		1995	Chinook	Fall	1994	BCW-94-COL	5,030	No CWT		2	210	Research - Bureau of Reclamation, Red Bluff
4	5	19	1995	Chinook	Fall	1994	BCW-94-COL	303,302	No CWT		2.5	158	Research - NCVFRO, Red Bluff
4	6	25	1995	Chinook	Fall	1994	BCW-94-COL	11,842,260	Partial	05111208, 05111207, 05111206	2.5-3	122	Battle Creek
4	20		1995	Chinook	Fall	1994	BCW-94-COL	9,969	No CWT		2.5	158	Research - Bureau of Reclamation, Red Bluff
6	16		1995	Chinook	Late-Fall	1995	B&K-95-COL	4,747	No CWT		2	264	Research - Bureau of Reclamation, Red Bluff
11	9		1995	Chinook	Late-Fall	1995	B&K-95-COL	126,584	Complete	062827, 064110	5-5.5	17	Battle Creek
11	20		1995	Chinook	Late-Fall	1995	B&K-95-COL	2,073	No CWT		5.33	17	Research -CDFG,Byron
12	8		1995	Chinook	Late-Fall	1995	B&K-95-COL	140,814	Complete	064107, 064109	5-5.5	16	Battle Creek
12	21		1995	Chinook	Winter	1995	SRW-95-COL	51,267	Complete	05111300, 05111301, 05111302, 05111303, 05111304, 05111305, 05111306, 05111307, 05111308, 05111509, 05111309, 05111310, 05111311, 05111312, 05111313, 05111314, 05111315, 05111401, 05111402, 05111403, 05111414, 05111413, 05111501, 05111405, 05111406, 05111407, 05111408, 05111502, 05111409, 05111410, 05111411, 05111412, 05111413, 05111404	2-2.5	183	Caldwell Park - Sacramento River
1	2	10	1996	Chinook	Late-Fall	1995	B&K-95-COL	529,845	Complete	[illegible], [illegible], 064118, [illegible], 064117, [illegible], [illegible], 064116	5-6	14	Battle Creek
1	9	16	1996	Chinook	Late-Fall	1995	B&K-95-COL	133,721	Complete	064112, 064113, 064114, 064111	5.5-6	13	Delta Study-Port Chicago, Courtland, Georgiana Slough, Ryde-Koket

Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
1	17		1996	Chinook	Fall	1995	BCW-95-COL	2,085	No CWT		1.5-2	521	Research - Bureau of Reclamation, Red Bluff
1	29		1996	Chinook	Fall	1995	BCW-95-COL	1,319,814	No CWT		1.5-2	527	Red Bluff - Sacramento River
2	8	28	1996	Chinook	Fall	1995	BCW-95-COL	5,222,300	No CWT		1.5-2	457	Red Bluff - Sacramento River
3	5	15	1996	Chinook	Fall	1995	BCW-95-COL	1,001,507	No CWT		1.5-2	432	Red Bluff - Sacramento River
3	13		1996	Chinook	Fall	1995	BCW-95-COL	4,840	No CWT		1.5-2	372	Research - Bureau of Reclamation, Red Bluff
3	14	29	1996	Chinook	Fall	1995	BCW-95-COL	8,210,230	Partial	0501020114, 0501020116	2.5-3	131	Battle Creek
4	24		1996	Chinook	Winter	1995	SRW-95-COL	332	Complete	05111414, 05111415, 01111405, 05111406, 05111408, 05111409, 05111410, 05111411, 05111412, 05111413, 05111501, 05111301, 05111302, 05111303, 05111304, 05111305, 05111306, 05111307, 05111308, [illegible], 05111407, 05111309, 05111310, 05111404, 05111311, 05111312, 05111313, 05111314, 05111401, 05111402, 05111403	4.31	31	Steinhart Aquarium - Captive Broodstock Program
3	27		1996	Chinook	Winter	1995	SRW-95-COL	316	Complete	05111414, 05111415, 01111406, 05111408, 05111408, 05111409, 05111410, 05111411, 05111412, 05111413, 05111501, 05111301, 05111302, 05111303, 05111304, 05111305, 05111306, 05111307, 05111308, [illegible], 05111407, 05111309, 05111310, 05111404, 05111311, 05111312, 05111313, 05111314, 05111401, 05111402, 05111403	3.5-4	45	Bodega Bay Marine Lab. - Captive Broodstock Program
4	15		1996	Chinook	Fall	1995	BCW-95-COL	7,044	No CWT		2.5	156	Research - Bureau of Reclamation, Red Bluff
4	22	23	1996	Chinook	Fall	1995	BCW-95-COL	4,144,723	Partial	0501020201	2.5-3.0	147-69	Battle Creek
8	27		1996	Chinook	Late-Fall	1996	B&K-96-COL	500	No CWT		4.1	37	Research- Bureau of Reclamation
9	23		1996	Chinook	Late-Fall	1996	B&K-96-COL	4,556	No CWT		4.5	27	Research- Bureau of Reclamation
11	7		1996	Chinook	Late-Fall	1996	B&K-96-COL	127,460	Complete	054232, 054233	3.9-4.1	40-37	Battle Creek
12	2		1996	Chinook	Late-Fall	1996	B&K-96-COL	55,425	Complete	054231	4	36	Miller Park - Sacramento River
12	10		1996	Chinook	Late-Fall	1996	B&K-96-COL	123,015	Complete	054234, 054235	4.2	33	Battle Creek
12	30		1996	Chinook	Late-Fall	1996	B&K-96-COL	51,049	Complete	054229	4.1	36	Benicia
1	9	17	1997	Chinook	Late-Fall	1996	B&K-96-COL	676,113	Complete	054123, 054124, 054125, 054126, 054127, 054236, 054237, 054238, 054239, 054240, 054241	4.5-6.4	27-9	Battle Creek
1	14		1997	Chinook	Late-Fall	1996	B&K-96-COL	46,046	Complete	054230	4.6	25	Miller Park - Sacramento River
1	30		1997	Chinook	Winter	1996	CAP-96-BML	2,365	Complete	0501020207	2.3	208	Caldwell Park - Sacramento River
2	4	13	1997	Chinook	Fall	1996	BCW-96-COL	1,970,072	No CWT		1.6-1.7	568-480	Hunters MHP - Sacramento River

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(inches)	(No.)/lb	Release Location
2	20	27	1997	Chinook	Fall	1996	BCW-96-COL	3,097,705	No CWT		1.7-1.9	480-390	Bow River Boat Ramp - Sacramento River
2	5	26	1997	Chinook	Fall	1996	BCW-96-COL	5,306	No CWT		1.3	758	Research - Bureau of Reclamation, Red Bluff
3	4	12	1997	Chinook	Fall	1996	BCW-96-COL	2,915,824	No CWT		1.7-1.8	480-416	Bow River Boat Ramp - Sacramento River
3	12		1997	Chinook	Winter	1996	CAP-96-BML	2,353	Complete	0601020097	2.2-2.4	231-178	Caldwell Park - Sacramento River
3	19		1997	Chinook	Fall	1996	BCW-96-COL	2,914	No CWT		1.9	367	Research - Bureau of Reclamation, Red Bluff
3	26	27	1997	Chinook	Late-Fall	1997	BCW-97-COL	2,066	No CWT		1.1-1.3	,515-1,0	Research - Misc.
3	27		1997	Chinook	Fall	1996	BCW-96-COL	34	No CWT		2.2	219	Research - Misc.
4	1	16	1997	Chinook	Fall	1996	BCW-96-COL	11,260,314	Partial	0601020208, 0601020209, 0601020210, 0601020211, 0601020212, 0601020213, 0601020214, 0601020215, 0601020301, 0601020302, 0601020303, 0601020304, 0601020305, 0601020306, 0601020307, 0601020308, 0601020309, 0601020310, 0601020311, 0601020312, 0601020313, 0601020314, 0601020315, 0601020401, 0601020402	2.7-3.1	125-78	Battle Creek
4	7	10	1997	Chinook	Late-Fall	1997	BCW-97-COL	7,652	No CWT		1.1	1,515	Research - Misc.
5	2		1997	Chinook	Fall	1996	BCW-96-COL	50	No CWT		2.7	131	Research - Misc.
5	2		1997	Chinook	Late-Fall	1997	BCW-97-COL	200	No CWT		1.7	500	Research - Misc.
5	5	22	1997	Chinook	Late-Fall	1997	BCW-97-COL	3,040	No CWT		2.1	255	Research - Bureau of Reclamation, Red Bluff
5	6		1997	Chinook	Fall	1996	BCW-96-COL	1,181,661	Partial	0601020403, 0601020404, 0601020405	2.9-3.0	100-89	Battle Creek
6	10		1997	Chinook	Late-Fall	1997	BCW-97-COL	822	No CWT		2.7	125	Research - UC Davis
6	25		1997	Chinook	Late-Fall	1997	BCW-97-COL	1,907	No CWT		3.1	80	Research - Bureau of Reclamation, Red Bluff
11	10		1997	Chinook	Late-Fall	1997	BCW-97-COL	141,769	Complete	[illegible]	4.7	24	Battle Creek
12	4		1997	Chinook	Late-Fall	1997	BCW-97-COL	64,501	Complete	[illegible]	4.1	35	Georgiana Slough
12	5		1997	Chinook	Late-Fall	1997	BCW-97-COL	49,740	Complete	[illegible]	4.0	37	Ryde
12	9		1997	Chinook	Late-Fall	1997	BCW-97-COL	130,405	Complete	[illegible]	4.2	34	Battle Creek
12	29		1997	Chinook	Late-Fall	1997	BCW-97-COL	50,611	Complete	[illegible]	4.1	35	Port Chicago
1	12	22	1998	Chinook	Late-Fall	1997	BCW-97-COL	582,175	Complete	[illegible]	5.4-5.6	16-15	Battle Creek
1	13		1998	Chinook	Late-Fall	1997	BCW-97-COL	68,962	Complete	[illegible]	5.5	15	Georgiana Slough
1	14		1998	Chinook	Late-Fall	1997	BCW-97-COL	50,060	Complete	[illegible]	5.6	14	Ryde
1	14		1998	Chinook	Late-Fall	1997	BCW-97-COL	315	Complete	[illegible]	5.6	14	Research - to CDFG

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Appendix 10A. Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.

Distribution Date											Size		
Month	First Date	Last Date	Year	Species	Race	BY	Lot No.	Number Released	CWT Status	CWT Code	(Inches)	(No.)/lb	Release Location
1	8		1998	Chinook	Fall	1997	BCW-97-COL	2,501	No CWT		1.3	1,131	Research - Bureau of Reclamation, Red Bluff
2	4	26	1998	Chinook	Fall	1997	BCW-97-COL	8,203,920	No CWT		1.7	500	Below RBDD
3	4	6	1998	Chinook	Fall	1997	BCW-97-COL	2,700,864	Partial	[illegible]	2.3	205	Battle Creek
3	12		1998	Chinook	Fall	1997	BCW-97-COL	2,000	No CWT		2.1	272	Research - Bureau of Reclamation, Red Bluff
3	31		1998	Chinook	Fall	1997	BCW-97-COL	3,570,654	Partial	[illegible]	2.5-2.7	156-125	Battle Creek
4	7	23	1998	Chinook	Fall	1997	BCW-97-COL	6,503,681	Partial	[illegible]	2.3-2.9	205-104	Battle Creek
4	8		1998	Chinook	Fall	1997	BCW-97-COL	2,040	No CWT		2.3	205	Research - Bureau of Reclamation, Red Bluff
4	24		1998	Chinook	Winter	1997	CAP-97-BML	21,271	Complete	0601011512	3.1	86	Caldwell Park - Sacramento River
8	5		1998	Chinook	Winter	1997	CAP-97-BML	5,042	No CWT		5.4	16	Steinhart Aquarium - Display
9	16		1998	Chinook	Winter	1997	CAP-97-BML	5,024	No CWT		6.5	9	Steinhart Aquarium - Display
10	13		1998	Chinook	Winter	1997	CAP-97-BML	4,032	No CWT		7.3		Steinhart Aquarium - Display ??
4	23		1998	Chinook	Late-Fall	1998	BCW-98-COL	4,407	No CWT		1.3	1,131	Research - Bureau of Reclamation, Red Bluff
6	3		1998	Chinook	Late-Fall	1998	BCW-98-COL	2,167	No CWT		2.0	313	Research - Bureau of Reclamation, Red Bluff
6	26		1998	Chinook	Late-Fall	1998	BCW-98-COL	5,104	No CWT		2.3	205	Research-NCVFWO
7	8		1998	Chinook	Late-Fall	1998	BCW-98-COL	125,892	No CWT				CNFH - Abatement Pond
8	7		1998	Chinook	Late-Fall	1998	BCW-98-COL	2,696	No CWT		3.0	93	Research - Bureau of Reclamation, Red Bluff
8	13		1998	Chinook	Late-Fall	1998	BCW-98-COL	632	No CWT		3.2	76	Research - Misc.
9	14		1998	Chinook	Late-Fall	1998	BCW-98-COL	2,088	No CWT		3.8	45	Research - Bureau of Reclamation, Red Bluff
11	12		1998	Chinook	Late-Fall	1998	BCW-98-COL	140,038	Complete	062309, 062311	4.4	29	Battle Creek
12	1	29	1998	Chinook	Late-Fall	1998	BCW-98-COL	141,568	Complete	062308, 062312	4.7-4.8	24-22	Georgiana Slough
12	2	30	1998	Chinook	Late-Fall	1998	BCW-98-COL	101,053	Complete	062320, 062321	4	40	Ryde
12	15		1998	Chinook	Late-Fall	1998	BCW-98-COL	131,852	Complete	062316, 062317	4.1	36	Battle Creek
12	22		1998	Chinook	Late-Fall	1998	BCW-98-COL	50,217	Complete	062322	4	40	Port Chicago
1	4		1999	Chinook	Late-Fall	1998	BCW-98-COL	537,812	Complete	062310, 062313, 062314, 062315, 062318, 062319, 064128, 064129	4.7-5.1	24-19	Battle Creek
1	28		1999	Chinook	Winter	1998	WCS-SRW-98-LIV	153,908	Complete	[illegible]	2.8-3.5	119-58	Caldwell Park - Sacramento River
3	18		1999	Chinook	Winter	1998	WCS-SRW-98-LIV	503					Bodega Bay Marine Lab. - Captive Broodstock Program
3	18		1999	Chinook	Winter	1998	WCS-SRW-98-LIV	504					Steinhart Aquarium - Captive Broodstock Program
1	12		1999	Chinook	Fall	1998	BCW-98-COL	3,205	No CWT		1.5	735	Research - Bureau of Reclamation, Red Bluff
1	29		1999	Chinook	Fall	1998	BCW-98-COL	384,882	No CWT		1.4	833	Bow River Boat Ramp - Sacramento River
1	29		1999	Chinook	Fall	1998	BCW-98-COL	370,191	No CWT		1.4	833	Woodson Bridge - Sacramento River
3	1		1999	Chinook	Fall	1998	BCW-98-COL	3,371	No CWT		1.4	833	Research - Bureau of Reclamation, Red Bluff
3	3		1999	Chinook	Fall	1998	BCW-98-COL	481,715	Partial	[illegible]	2	290	Battle Creek
3	23		1999	Chinook	Fall	1998	BCW-98-COL	3,093	No CWT		1.6	625	Research - Bureau of Reclamation, Red Bluff

Appendix 10A. **Distribution of chinook salmon from Coleman National Fish Hatchery (NFH) from 1941 through January 2000. Data include release date(s), species, race (run), brood year (BY), production lot number, number released, coded-wire tag (CWT) status, CWT code, size at release (forklength [inches] and number per pound), and release location. Information on this table may be cross-tabulated with Coleman NFH spawning data (Appendix 6A) using "CWT code" as an index field.**

Distribution Date													
	First	Last						Number	CWT	CWT	Size		
Month	Date	Date	Year	Species	Race	BY	Lot No.	Released	Status	Code	(inches)	(No.)/lb	Release Location
3	31		1999	Chinook	Fall	1998	BCW-98-COL	926,018	Partial	0601021015	2.3	192	Battle Creek
4	9		1999	Chinook	Fall	1998	BCW-98-COL	3,510	No CWT		2.2	231	Research - Battle Creek
4	20	28	1999	Chinook	Fall	1998	BCW-98-COL	11,623,260	Partial	0601021007-0601021014, 0601021101-0601021115	3.2-3.5	76-58	Battle Creek
4	23		1999	Chinook	Fall	1998	BCW-98-COL	221	No CWT		2.9	100	Research - CDFG
5	11		1999	Chinook	Late-Fall	1999	BCW-99-COL	2,001	No CWT		1.4	833	Research - Bureau of Reclamation, Red Bluff
10	14		1999	Chinook	Late-Fall	1999	BCW-99-COL	5,137	Complete	065120	4.5	27	Research - NCVFWO, Red Bluff
11	10		1999	Chinook	Late-Fall	1999	BCW-99-COL	74,211	Complete	065140	4.8	22	Battle Creek
12	9		1999	Chinook	Late-Fall	1999	BCW-99-COL	80,796	Complete	065141	5.2	18	Battle Creek
12	10		1999	Chinook	Late-Fall	1999	BCW-99-COL	69,690	Complete	065130	6.0	11	Georgiana Slough
12	11		1999	Chinook	Late-Fall	1999	BCW-99-COL	53,966	Complete	065132	5.5	15	Ryde
12	20		1999	Chinook	Late-Fall	1999	BCW-99-COL	69,371	Complete	065131	5.5	15	Georgiana Slough
12	21		1999	Chinook	Late-Fall	1999	BCW-99-COL	83,383	Complete	065214	5.4	16	Battle Creek
12	21		1999	Chinook	Late-Fall	1999	BCW-99-COL	50,348	Complete	065133	6.6	12	Ryde
12	29		1999	Chinook	Late-Fall	1999	BCW-99-COL	52,349	Complete	065134	5.5	15	Port Chicago
1	4		2000	Chinook	Late-Fall	1999	BCW-99-COL	500,085	Complete	065207, 065208, 065209, 065210, 065211, 065212	5-5.6	19-15	Battle Creek
1	14		2000	Chinook	Late-Fall	1999	BCW-99-COL	230	Complete	065213	5.7	13	Research - Stockton
1	14		2000	Chinook	Late-Fall	1999	BCW-99-COL	83,117	Complete	065213	5.7	13	Battle Creek
1	27		2000	Chinook	Winter	1999	WCS-SRW-99-LIV	26,522	Complete	0601021205-0601021215, 0601021301-0601021306	3.8	46	Caldwell Park - Sacramento River
1	27		2000	Chinook	Winter	1999	WCS-BML/SRW-99-LIV	4,318	Complete	0601021307	2.7	123	Caldwell Park - Sacramento River

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1948	1948	STT	KESWICK TRAP	16	11,211	4	SACRAMENTO RIVER		
1948	1951	STT	KESWICK TRAP	16	27	"ADULTS"	SACRAMENTO RIVER		
1949	1949	STT	COLEMAN BROODSTOCK (Lot 16)	20	41,291	3-4	SACRAMENTO RIVER		
1949	1950	STT	COLEMAN BROODSTOCK (Lot 16)	20	1,590	6	SACRAMENTO RIVER		
1949	1950	STT	COLEMAN BROODSTOCK (Lot 16)	20	24	"ADULTS"	SACRAMENTO RIVER		
1949	1951	STT	COLEMAN BROODSTOCK (Lot 16)	20	83	"ADULTS"	SACRAMENTO RIVER		
1950	1950	KAM	BRITISH COLUMBIA, CAN	21	934	6	SHASTA LAKE		
1950	1950	STT	COLEMAN BROODSTOCK (Lot 16)	24	136,414	3	SACRAMENTO RIVER		
1950	1950	STT	COLEMAN BROODSTOCK (Lot 16)	24	3,971	4	SACRAMENTO RIVER		
1951	1951	KAM	BRITISH COLUMBIA, CAN	26	25,232	4	SHASTA LAKE		
1951	1950	RBT	POCATELLO, ID	25	94,000	2			
1951	1951	STT	COLEMAN BROODSTOCK	29	110,197	1	SACRAMENTO RIVER		
1952	1952	KAM	BRITISH COLUMBIA, CAN	31	71,654	4	SHASTA LAKE		
1953	1953	KAM	BRITISH COLUMBIA, CAN	37	51,778	5	SHASTA LAKE		
1953	1952	KAM	GREENOUGH, MT	38	28,493	6	SHASTA LAKE		
1953	1953	STT	BATTLE CREEK	35	63,662	6	SACRAMENTO RIVER		
1953	1954	STT	BATTLE CREEK	40	153,025	5-6	SACRAMENTO RIVER		
1954	1954	KAM	MISSOULA, MT	41 & 42	84,091	5-6	SHASTA LAKE		
1954	1955	STT	BATTLE CREEK	44	178,259	5-6	SACRAMENTO RIVER		
1956	1956	STT	BATTLE CREEK AND KESWICK	5CM	206,071	6	SACRAMENTO RIVER		
1956	1956	STT	BATTLE CREEK AND KESWICK	5CM	79,804	5-6	SACRAMENTO RIVER		
1956	1955	STT	BATTLE CREEK AND KESWICK	5CM	47,627	EYED EGGS	NIMBUS HATCHERY		
1956	1956	RBT	HAGARMAN, ID	5H	16,419	5-6			
1956	1955	STT	BATTLE CREEK	5CM	67,141	7-8	SACRAMENTO RIVER		
1956	Oct-57	STT	BATTLE CREEK AND KESWICK	6CM	16,265	2	SACRAMENTO RIVER		
1956	1957	STT	BATTLE CREEK AND KESWICK	6CM	121,699	6	SACRAMENTO RIVER		
1956	Jan-57	STT	BATTLE CREEK AND KESWICK	6CM	109,762	4	MILL CREEK - SACRAMENTO RIVER		
1956	Apr-57	STT	BATTLE CREEK AND KESWICK	6CM	2,190	6	INDIAN SPRINGS CREEK - SACRAMENTO RIVER		
1956	Apr-57	STT	BATTLE CREEK AND KESWICK	6CM	2,250	6	UPPER DRY CREEK - SACRAMENTO RIVER		
1956	Apr-57	STT	BATTLE CREEK AND KESWICK	6CM	560	6	LOWER DRY CREEK - SACRAMENTO RIVER		
1956	Aug-57	STT	BATTLE CREEK AND KESWICK	6CM	783	6-7	SACRAMENTO RIVER		
1957	Dec-57	STT	BATTLE CREEK AND KESWICK	7-CM-54	33,531	6	SACRAMENTO RIVER		
1957	Jan-58	STT	BATTLE CREEK AND KESWICK	7-CM-54	94,970	5-6	SACRAMENTO RIVER		
1957	Apr-58	STT	BATTLE CREEK AND KESWICK	7-CM-54	5,037	7-8	SACRAMENTO RIVER		
1957	1956	RBT	HAGARMAN, ID	6H	42,000	EYED EGGS	CAL DEPT. FISH AND GAME		
1958	Jul-58	STT	BATTLE CREEK AND KESWICK	8-CM-59	6,987	1-2	SACRAMENTO RIVER		
1958	1957	KAM	COLEMAN BROODSTOCK	7-CM	2,456	6	SACRAMENTO RIVER		
1958	1957	KAM	FORT KLAMATH, OR	7-ORE-55	23,804	3	SHASTA LAKE		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases Number	Coded-wire Tagged Releases Tag Codes
1958	May-58	KAM	FORT KLAMATH, OR	7-ORE-55	3,172	3-4	BIG SPRING / NEVADA		
1958	May-58	KAM	FORT KLAMATH, OR	7-ORE-55	37,952	3-4	SHASTA LAKE		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	131,712	5	SACRAMENTO RIVER		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	84,171	6	SACRAMENTO RIVER		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	25,661	5	FEATHER RIVER		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	24,451	6	CLEAR CREEK - SACRAMENTO RIVER		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	1,414	6	MILL CREEK - SACRAMENTO RIVER		
1959	Mar-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	15,051	6	CHICO CREEK - SACRAMENTO RIVER		
1959	Apr-59	STT	BATTLE CREEK AND KESWICK	8-CM-59	6,318	6	UPPER DRY CREEK - SACRAMENTO RIVER		
1959	Mar-60	KAM	COLEMAN, CA	8-CM-65	14,964	8	SHASTA LAKE		
1959	Jan-59	KAM	COLEMAN, CA	8-CM-65	502	6-7	SHASTA LAKE		
1959	Apr-59	KAM	COLEMAN, CA	8-CM-65	9,207	5-6	SHASTA LAKE		
1959	1958	RBT	MOUNT SHASTA, CA	8-CAL-58	18,991	2			
1959	1959	KAM	DIAMOND LAKE, OR	8-ORE-61	19,438	5-6			
1960	1960	STT	BATTLE CREEK AND KESWICK	9-CM-66	30,069	4	SACRAMENTO RIVER		
1960	Feb-60	STT	BATTLE CREEK AND KESWICK	9-CM-66	50,076	4	CLEAR CREEK - SACRAMENTO RIVER		
1960	1960	STT	BATTLE CREEK AND KESWICK	9-CM-66	221,356	5	SACRAMENTO RIVER		
1960	Mar-60	STT	BATTLE CREEK AND KESWICK	9-CM-66	25,091	4	FEATHER RIVER		
1960	Mar-60	STT	BATTLE CREEK AND KESWICK	9-CM-66	30,226	5	MILL CREEK - SACRAMENTO RIVER		
1960	Mar-60	STT	BATTLE CREEK AND KESWICK	9-CM-66	15,348	6	CHICO CREEK - SACRAMENTO RIVER		
1960	Mar-61	STT	BATTLE CREEK AND KESWICK	9-CM-71	5,015	5	CHICO CREEK - SACRAMENTO RIVER		
1960	Mar-61	STT	BATTLE CREEK AND KESWICK	9-CM-71	10,018	5	FEATHER RIVER		
1960	Mar-61	STT	BATTLE CREEK AND KESWICK	9-CM-71	97,344	5	SACRAMENTO RIVER		
1960	Apr-60	KAM	DIAMOND LAKE, OR	9-ORE-67	27,372	5	SHASTA LAKE		
1960	Feb-61	KAM	BATTLE CREEK	9-CM-70	17,684	8	SHASTA LAKE		
1960	Oct-61	STT	BATTLE CREEK AND KESWICK	1-CN-77	62,889	6	SACRAMENTO RIVER		
1960	Nov-61	STT	BATTLE CREEK AND KESWICK	1-CN-77	56,250	6	SACRAMENTO RIVER		
1960	Dec-61	STT	BATTLE CREEK AND KESWICK	1-CN-77	58,840	6	SACRAMENTO RIVER		
1960	Jan-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	35,217	6-7	FEATHER RIVER		
1960	Jan-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	12,192	6	CHICO CREEK - SACRAMENTO RIVER		
1960	Jan-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	7,270	6-7	RESEARCH - ARMY CORP OF ENG.		
1960	Jan-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	152,130	6-7	SACRAMENTO RIVER		
1960	Feb-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	64,036	5-6	SACRAMENTO RIVER		
1960	Mar-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	35,064	5-6	MILL CREEK - SACRAMENTO RIVER		
1960	Mar-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	25,226	5-6	DEER CREEK - SACRAMENTO RIVER		
1960	Mar-62	STT	BATTLE CREEK AND KESWICK	1-CN-77	43,763	5-6	SACRAMENTO RIVER		
1961	Feb-61	KAM	DIAMOND LAKE, OR	0-ORE-72	17,684	4	SHASTA LAKE		
1962	Nov-62	STT	BATTLE CREEK AND KESWICK	2-CN-81	66,150	6-7	SACRAMENTO RIVER		
1962	Dec-62	STT	BATTLE CREEK AND KESWICK	2-CN-81	160,650	6-7	SACRAMENTO RIVER		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1962	Jan-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	29,220	6-7	SACRAMENTO RIVER		
1962	Feb-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	243,730	6-7	SACRAMENTO RIVER		
1962	Feb-53	STT	BATTLE CREEK AND KESWICK	2-CN-81	35,210	6-7	FEATHER RIVER		
1962	Feb-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	9,960	6-7	CHICO CREEK - SACRAMENTO RIVER		
1962	Mar-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	366,146	5-6	SACRAMENTO RIVER		
1962	Apr-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	21,252	5	DEER CREEK - SACRAMENTO RIVER		
1962	Apr-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	42,966	5	MILL CREEK - SACRAMENTO RIVER		
1962	Apr-63	STT	BATTLE CREEK AND KESWICK	2-CN-81	218,257	5	SACRAMENTO RIVER		
1962	Oct-61	KAM	COLEMAN BROODSTOCK	1-CN-76	50,031	7	SACRAMENTO RIVER		
1962	Jan-62	KAM	COLEMAN BROODSTOCK	1-CN-76	35,217	6	SHASTA LAKE		
1962	Nov-62	KAM	COLEMAN BROODSTOCK	2-CN-80	34,302	6-7	SACRAMENTO RIVER		
1962	Nov-62	KAM	COLEMAN BROODSTOCK	2-CN-80	53,340	6-7	SHASTA LAKE		
1962	Dec-63	KAM	COLEMAN BROODSTOCK	2-CN-80	40,210	6	SACRAMENTO RIVER		
1962	Apr-63	KAM	COLEMAN BROODSTOCK	2-CN-80	9,850	8	MILITARY BASES		
1963	Oct-63	STT	BATTLE CREEK AND KESWICK	3-CN-86	6,300	6-7	SACRAMENTO RIVER		
1963	Jan-64	STT	BATTLE CREEK AND KESWICK	3-CN-86	22,200	7-8	SACRAMENTO RIVER		
1963	Feb-64	STT	BATTLE CREEK AND KESWICK	3-CN-86	181,000	6-7	SACRAMENTO RIVER		
1963	Feb-64	STT	BATTLE CREEK AND KESWICK	3-CN-86	25,000	6-7	FEATHER RIVER		
1963	Mar-64	STT	BATTLE CREEK AND KESWICK	3-CN-86	10,000	6-7	SACRAMENTO RIVER		
1963	Mar-64	STT	BATTLE CREEK AND KESWICK	3-CN-86	222,400	6-7	SACRAMENTO RIVER		
1963	1963	KAM	COLEMAN BROODSTOCK	3-CN-84	66,132	7			
1963	Nov-63	KAM	COLEMAN BROODSTOCK	3-CN-84	37,600	8	SACRAMENTO RIVER		
1963	Dec-63	KAM	COLEMAN BROODSTOCK	3-CN-84	33,300	7	SHASTA LAKE		
1963	Nov-64	KAM	COLEMAN BROODSTOCK	3-CN-84	26,000	6	ENGLE LAKE		
1963	Nov-64	KAM	COLEMAN BROODSTOCK	3-CN-84	1,000	8	MILITARY BASE		
1963	Nov-64	KAM	COLEMAN BROODSTOCK	3-CN-84	25,000	7	WHISKEY TOWN LAKE		
1963	Nov-64	KAM	COLEMAN BROODSTOCK	3-CN-84	95,500	7	SHASTA LAKE		
1963	Nov-64	KAM	COLEMAN BROODSTOCK	3-CN-84	87,400	6-7	SACRAMENTO RIVER		
1963	Feb-65	KAM	COLEMAN BROODSTOCK	3-CN-84	7,000	10	SHASTA LAKE		
1964	Oct-64	STT	BATTLE CREEK AND KESWICK	4-CN-91	1,400	10	SACRAMENTO RIVER		
1964	Nov-64	STT	BATTLE CREEK AND KESWICK	4-CN-91	25,600	7	FEATHER RIVER		
1964	Nov-64	STT	BATTLE CREEK AND KESWICK	4-CN-91	20,400	6-7	CLEAR CREEK - SACRAMENTO RIVER		
1964	Dec-64	STT	BATTLE CREEK AND KESWICK	4-CN-91	177,800	6-7	SACRAMENTO RIVER		
1964	Jan-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	67,000	6-7	SACRAMENTO RIVER		
1964	Jan-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	25,000	6-7	FEATHER RIVER		
1964	Feb-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	231,200	6-7	SACRAMENTO RIVER		
1964	Mar-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	413,000	6-7	SACRAMENTO RIVER		
1964	Apr-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	5,000	8-9	MILITARY BASE		
1964	Apr-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	565,000	5-6	SACRAMENTO RIVER		

Appendix 10B. **Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.**

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1964	Jun-65	STT	BATTLE CREEK AND KESWICK	4-CN-91	500	1 / LB	SACRAMENTO RIVER		
1965	Mar-Apr 65	STT	BATTLE CREEK AND KESWICK	5-CN-96	785,000	EYED EGGS	CAL DEPT OF FISH AND GAME		
1964	Jan-64	KAM	COLEMAN NFH	4-CN-90	20,000	EYED EGGS	NEV DEPT OF FISH AND GAME		
1964	1965	KAM	COLEMAN NFH	4-CN-90	241,900	7			
1964	Jan-65	KAM	BATTLE CREEK	4-CN-90 or 5-CN-90	8,800	EYED EGGS	(KOREA) CAL DEPT OF FISH AND GAME,		
1964	Jan-65	KAM	BATTLE CREEK	4-CN-90 or 5-CN-90	26,000	EYED EGGS	WYOMING DEPT OF FISH AND GAME;		
1964	Jan-65	KAM	BATTLE CREEK	4-CN-90 or 5-CN-90	50,000	EYED EGGS	NEVADA DEPT OF FISH AND GAME;		
1965	Dec-65	STT	BATTLE CREEK AND KESWICK	5-CN-96	40,600	6	SACRAMENTO RIVER		
1965	Jan-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	25,000	6-7	MILL CREEK - SACRAMENTO RIVER		
1965	Jan-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	25,000	6-7	DEER CREEK - SACRAMENTO RIVER		
1965	Jan-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	64,000	6-7	SACRAMENTO RIVER		
1965	Feb-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	50,000	6-7	FEATHER RIVER		
1965	Feb-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	180,000	6-7	SACRAMENTO RIVER		
1965	Mar-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	423,700	6-7	SACRAMENTO RIVER		
1965	Apr-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	304,751	6-7	SACRAMENTO RIVER		
1965	Apr-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	3,200	8-9	MILITARY BASE		
1965	May-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	3,000	9	MILITARY BASE		
1965	May-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	197,900	6-7	SACRAMENTO RIVER		
1965	Jun-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	10,000	10	MILITARY BASE		
1965	Jun-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	167,400	6-7	SACRAMENTO RIVER		
1965	1965	STT	BATTLE CREEK AND KESWICK	-CN-92	1,900	1.6 / LB			
1965	Nov-65	KAM	BATTLE CREEK	5-CN-95	26,000	8	SHASTA LAKE		
1965	Dec-65	KAM	BATTLE CREEK	5-CN-95	117,100	7	SHASTA LAKE		
1965	Jan-66	KAM	BATTLE CREEK	5-CN-95	85,200	6	SHASTA LAKE		
1965	Jan-66	KAM	BATTLE CREEK	5-CN-95	30,000	6	WHISKEY TOWN LAKE		
1965	Mar-66	KAM	BATTLE CREEK	5-CN-95	1,000	9	SHASTA LAKE		
1966	Feb-66	KAM	BATTLE CREEK	6-CN-3	97,000	EYED EGGS	CAL DEPT OF FISH AND GAME		
1966	Mar-66	KAM	BATTLE CREEK	6-CN-3	25,000	EYED EGGS	CAL DEPT OF FISH AND GAME		
1966	Feb-66	KAM	BATTLE CREEK	6-CN-3	50,000	EYED EGGS	NEV DEPT OF FISH AND GAME		
1965	Jan-Mar, Jun 66	STT	BATTLE CREEK AND KESWICK	5-CN-96	650,600	6	SACRAMENTO RIVER @ JELLY'S FERRY		
1965	Jan-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	25,000	6	MILL CREEK - SACRAMENTO RIVER		
1965	Jan-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	25,000	6	DEER CREEK - SACRAMENTO RIVER		
1965	Jan-Mar 66	STT	BATTLE CREEK AND KESWICK	5-CN-96	70,700	6	SACRAMENTO RIVER @ REDDING		
1965	Feb-66	STT	BATTLE CREEK AND KESWICK	5-CN-96	50,000	6	FEATHER RIVER		
1965	Apr-Jun 66	STT	BATTLE CREEK AND KESWICK	5-CN-96	405,550	3	SACRAMENTO RIVER @ PRINCETON		
1965	Apr-Jun 66	STT	BATTLE CREEK AND KESWICK	5-CN-96	16,200	11	MILITARY BASES		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (In.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1965	Apr-66	STT	BATTLE CREEK AND KESWICK	5-CN-66	177,000	6	BATTLE CREEK - SACRAMENTO RIVER		
1965	Feb-Mar 66	STT	BATTLE CREEK AND KESWICK	5-CN-66	75,300	6	SACRAMENTO RIVER @ BALLS FERRY		
1967	Feb-67	KAM	COLEMAN BROODSTOCK	7-CN-10	179,600	EYED EGGS	CAL DEPT OF FISH AND GAME		
1967	Feb-67	KAM	COLEMAN BROODSTOCK	7-CN-10	50,000	EYED EGGS	NEV DEPT OF FISH AND GAME		
1967	Feb-67	KAM	COLEMAN BROODSTOCK	7-CN-10	92,000	EYED EGGS	QUILCENE NFH, WA		
1966	Mar-67	KAM	COLEMAN BROODSTOCK	6-CN-3	41,890	7	WHISKEYTOWN LAKE		
1966	Dec 66 - Mar 67	KAM	COLEMAN BROODSTOCK	6-CN-3	302,680	7-8	SHASTA LAKE		
1966	May-Jun 67	RBT	WINTHROP, WA	6-WP-5	21,980	9-11	MILITARY BASES		
1966	May-Jun 67	RBT	WINTHROP, WA	6-WP-5	10,020	11	TULE RIVER INDIAN RES.		
1966	Jun-67	RBT	WINTHROP, WA	6-WP-5	3,500	9	SACRAMENTO RIVER		
1965	Aug-66	STT	SPILLWAY	6-CN-8	3,750	12	SACRAMENTO RIVER @ BALLS FERRY;		
1966	Dec 66 - Mar 67	STT	BATTLE CREEK	6-CN-4	569,600	7	SACRAMENTO RIVER @ BATTLE CREEK		
1966	Jan-67	STT	BATTLE CREEK	6-CN-4	125,150	7	SACRAMENTO RIVER @ REDDING		
1966	Feb-67	STT	BATTLE CREEK	6-CN-4	48,000	7	FEATHER RIVER		
1966	Feb-67	STT	BATTLE CREEK	6-CN-4	214,100	7	SACRAMENTO RIVER @ BALLS FERRY		
1966	Mar-67	STT	BATTLE CREEK	6-CN-4	27,190	7	DEER CREEK - SACRAMENTO RIVER		
1966	Mar-67	STT	BATTLE CREEK	6-CN-4	27,190	7	MILL CREEK - SACRAMENTO RIVER		
1966	Apr-67	STT	BATTLE CREEK	6-CN-4	99,690	7	SACRAMENTO RIVER @ JELLY'S FERRY		
1967	Jan-May 68	KAM	COLEMAN BROODSTOCK	7-CN-10	377,500	9	SHASTA LAKE		
1967	Feb-68	KAM	COLEMAN BROODSTOCK	7-CN-10	30,500	9	WHISKEYTOWN LAKE		
1967	Mar-68	KAM	COLEMAN BROODSTOCK	7-CN-10	3,500	8	BERRYESSA LAKE		
1967	Apr-68	KAM	COLEMAN BROODSTOCK	7-CN-10	3,500	8	WEST VALLEY INDIAN RES.		
1966	Aug-67	RBT	ENNIS, MT	7-DS-14	3,003	9	MILITARY BASES		
1967	Feb, Jun 68	RBT	ENNIS, MT	7-E-12	12,000	11-13	WHISKEYTOWN LAKE		
1967	Apr-Jun 68	RBT	ENNIS, MT	7-E-12	8,000	11	LA JOLLA INDIAN RES.		
1967	Apr-May 68	RBT	ENNIS, MT	7-E-12	25,333	10-11	MILITARY BASES		
1967	Apr-Jun 68	RBT	ENNIS, MT	7-E-12	15,000	11	TULE RIVER (RESERVATION)		
1968	May-68	KAM	COLEMAN BROODSTOCK	8-CM-16	126,078	2	CAL. DEPT OF FISH AND GAME		
1967	Sep 67 - Mar 68	STT	BATTLE CREEK	7-CN-11	798,000	7	SACRAMENTO RIVER @ JELLY'S FERRY		
1967	Jan-Mar 68	STT	BATTLE CREEK	7-CN-11	400,000	6-7	SACRAMENTO RIVER @ BALLS FERRY		
1967	Jan-Mar 68	STT	BATTLE CREEK	7-CN-11	200,000	7	SACRAMENTO RIVER @ BATTLE CREEK		
1967	Mar-68	STT	BATTLE CREEK	7-CN-11	20,000	6	MILL CREEK - SACRAMENTO RIVER		
1967	Mar-68	STT	BATTLE CREEK	7-CN-11	25,000	7	DEER CREEK - SACRAMENTO RIVER		
1968	Aug-68	KAM	COLEMAN BROODSTOCK	8-CM-16	10,000	4	BLUE LAKE INDIAN RES.		
1968	Aug 69; Jan-May 69	KAM	COLEMAN BROODSTOCK	8-CM-16	374,265	4-9	SHASTA LAKE AKA Lot # 8-CN-16		
1968	Feb-69	KAM	COLEMAN BROODSTOCK	8-CN-7	881	17	SHASTA LAKE		
1968	Jan-69	RBT	ENNIS, MT	8-E-19	40,000	9	WHISKEYTOWN		
1968	Apr-Jun 69	RBT	ENNIS, MT	8-E-19	9,738	9-10	LA JOLLA INDIAN RES.		
1968	Apr-Jun 69	RBT	ENNIS, MT	8-E-19	14,328	10	TULE RIVER INDIAN RES.		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1968	May-Jun 69	RBT	ENNIS, MT	8-E-19	25,161	8-11	MILITARY BASES		
1968	Oct 68 - May 69	STT	BATTLE CREEK	8-CN-18	1,022,845	4-7	SACRAMENTO RIVER @ BALLS FERRY		
1968	Jan-Jun 69	STT	BATTLE CREEK	8-CN-18	399,734	7-8	SACRAMENTO RIVER @ BATTLE CREEK		
1969	Sep-69	KAM	COLEMAN BROODSTOCK	9-CN-21	128	7	STEINHART AQUARIUM		
1969	Sep 69; Apr-May 70	KAM	COLEMAN BROODSTOCK	9-CN-21	517,310	5-9	SHASTA LAKE		
1969	Sep-69	KAM	COLEMAN BROODSTOCK	9-CN-21	61,650	5	KESWICK RESERVOIR		
1969	Feb-70	KAM	WINTHROP, WA	9-WP-24	1,437	10	SHASTA LAKE		
1969	May-70	KAM	COLEMAN BROODSTOCK	8-CN-7X	4,911	12-14	SHASTA LAKE		
1968	Jul-70	RBT	ENNIS, MT	8-E-19	9,508	11	TULE RIVER INDIAN RES.		
1968	Jul-Aug 70	RBT	ENNIS, MT	8-E-19	5,405	11	LA JOLLA INDIAN RES.		
1968	Sep-69	RBT	ENNIS, MT	8-E-19	1,898	12	KESWICK RESERVOIR		
1969	Sep-69	RBT	WINTHROP, WA	9-WP-24	31,008	6	KESWICK RESERVOIR		
1969	Nov 69; Jan-May 70	RBT	WINTHROP, WA	9-WP-24	30,128	7-9	MILITARY BASES		
1969	Feb-Apr 70	RBT	WINTHROP, WA	9-WP-24	7,200	8	LA JOLLA INDIAN RES.		
1969	Feb-Jun 70	RBT	WINTHROP, WA	9-WP-24	53,405	8-9	WHISKEYTOWN LAKE		
1969	Sep-69	RBT	Mt Whitney SFH, CDFG	9-UC-25	32,932	4	KESWICK RESERVOIR		
1969	Feb, Apr 70	STT	BATTLE CREEK	9-CN-22	325,853	7	SACRAMENTO RIVER @ RIO VISTA		
1969	Feb, Apr 70	STT	BATTLE CREEK	9-CN-22	329,717	7	SACRAMENTO RIVER @ BATTLE CREEK		
1971	Apr-70	KAM	COLEMAN BROODSTOCK	1-CN-33	1,311,000	Fry	DESTROYED DUE TO DETECTION OF IHN		
1970	Mar-Jun 71	KAM	COLEMAN BROODSTOCK	0-CN-27	60,759	9-10	WHISKEYTOWN LAKE		
1970	Apr-Jun 71	KAM	COLEMAN BROODSTOCK	0-CN-27	404,771	9-10	SHASTA LAKE		
1970	Apr-May 71	KAM	COLEMAN BROODSTOCK	0-CN-27	17,480	9	MILITARY BASES		
1968	Jul-Aug 71	RBT	WINTHROP, WA	9-WP-24	42,368	9-11	WHISKEYTOWN LAKE		
1970	Mar-71	RBT	ENNIS, MT	0-E-29	6,057	12	WHISKEYTOWN LAKE		
1970	Jul-70	RBT	ENNIS, MT	0-E-29	150	5	SAN FRANCISCO STATE UNIV.		
1970	ov-Dec 70; Jan-Mar 7	RBT	ENNIS, MT	0-E-29	5,004	9	MILITARY BASES		
1970	Jun-71	RBT	ENNIS, MT	0-UC-30	5,193	8	WHISKEYTOWN LAKE		
1970	Nov-70	STT	BATTLE CREEK & KESWICK	9-CN-28	77,927	4	YUBA RIVER		
1970	Feb-Mar 71	STT	BATTLE CREEK & KESWICK	9-CN-28	706,363	7	SACRAMENTO RIVER @ RIO VISTA		
1970	Feb-Apr 71	STT	BATTLE CREEK & KESWICK	9-CN-28	822,191	6-7	SACRAMENTO RIVER @ BATTLE CREEK		
1971	Feb-71	STT	BATTLE CREEK & KESWICK	0-CN-32	100,656	EE	NIMBUS HATCHERY		
1971	Jan, Apr 72	KAM	CLARK FORK HATCHERY, ID	1-UID-34	24,558	9-11	SHASTA LAKE		
1971	Apr-72	KAM	CLARK FORK HATCHERY, ID	1-UID-34	1,370	8-11	MILITARY BASES		
1970	Jul-Aug 71	RBT	CAL DEPT OF FISH AND GAME	0-UC-30	20,865	11	WHISKEYTOWN LAKE		
1970	ov-Dec 71; Jan-Mar 7	RBT	CAL DEPT OF FISH AND GAME	0-UC-30	5,010	8-9	TWO ROCKS RANCH, SONOMA CITY,		
1970	Jan, Apr 72	RBT	CAL DEPT OF FISH AND GAME	0-UC-30	78,589	9-11	SHASTA LAKE,		
1970	Mar-Apr 72	RBT	CAL DEPT OF FISH AND GAME	0-UC-30	15,376	9	WHISKEYTOWN LAKE		
1972	Jun-72	RBT	ENNIS, MT	2-EN-39	6,054	3	WHISKEYTOWN LAKE		
1971	Apr-May 72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	20,909	7	MILITARY BASES		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1971	Jan-72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	100	6	RESEARCH, SIMPSON LEE		
1971	Mar-May 72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	184,533	7-8	SHASTA LAKE		
1971	May-Jun 72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	52,679	7-8	WHISKEYTOWN LAKE		
1971	Sep 71; Apr 72	STT	BATTLE CREEK & KESWICK	0-CN-32	266,130	4	YUBA RIVER		
1971	Oct-71	STT	BATTLE CREEK & KESWICK	0-CN-32	62,685	4-5	SACRAMENTO RIVER @ LAKE REDDING PARK		
1971	Oct 71; Jan-Feb 72	STT	BATTLE CREEK & KESWICK	0-CN-32	316,678	5	BATTLE CREEK - SACRAMENTO RIVER		
1971	Mar-72	STT	BATTLE CREEK & KESWICK	0-CN-32	300	7	STEINHART AQUARIUM		
1971	Oct-71	STT	BATTLE CREEK & KESWICK	0-CN-32	97,978	5	SACRAMENTO RIVER @ JELLY'S FERRY		
1971	Oct 71; Jan-Apr 72	STT	BATTLE CREEK & KESWICK	0-CN-32	1,216,993	5-7	SACRAMENTO RIVER @ BALLS FERRY		
1971	Jan-72	STT	BATTLE CREEK & KESWICK	0-CN-32	20,794	7	SHASTA LAKE		
1971	Jan-Feb 72	STT	BATTLE CREEK & KESWICK	0-CN-32	63,571	7	SACRAMENTO RIVER @ ORD BEND		
1971	Feb-72	STT	BATTLE CREEK & KESWICK	0-CN-32	201,783	7	SACRAMENTO RIVER @ RIO VISTA		
1972	Feb-72	STT	BATTLE CREEK & KESWICK	1-CM-40	3,000	EYED EGGS	ARROYO GRANDE H.S. EXHIBIT		
1971	Mar-73	KAM	CLARK FORK HATCHERY, ID	1-UID-34	945	16	SHASTA LAKE		
1971	Jul-Aug 72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	32,428	8	WHISKEYTOWN LAKE		
1971	Jul-72	RBT	CAL DEPT OF FISH AND GAME	1-UC-36	4,060	9	TULE RIVER		
1972	Apr-Jun 73	RBT	ENNIS, MT	2-EN-39	267,036	8-9	SHASTA LAKE		
1972	Oct-72	RBT	ENNIS, MT	2-EN-39	30	6	SHASTA COLLEGE		
1972	Jan, Apr-May 73	RBT	ENNIS, MT	2-EN-39	25,273	8-10	MILITARY BASES		
1972	Apr-May 73	RBT	ENNIS, MT	2-EN-39	64,509	8-9	WHISKEYTOWN LAKE		
1972	Nov 72; Feb-Mar 73	RBT	ENNIS, MT	2-EN-39 or 1-EN-39	2,000	9	MILITARY BASES;		
1972	Mar-73	RBT	ENNIS, MT	2-EN-39 or 1-EN-39	71,818	9	SHASTA LAKE;		
1972	ug-Sep 72; Feb-Mar 7	STT	NIMBUS HATCHERY, CA	1-UCA-41	1,275	4	RESEARCH, SIMPSON LEE CORP.		
1972	Jul-72	STT	NIMBUS HATCHERY, CA	1-UCA-41	40	4	DIAMOND NATIONAL		
1972	Mar-Apr 73	STT	NIMBUS HATCHERY, CA	1-UCA-41	490,441	6	SACRAMENTO RIVER @ BALLS FERRY		
1972	Dec 72; Feb 73	STT	NIMBUS HATCHERY, CA	1-UCA-41	1,000	5	TIBURON RESEARCH STATION		
1972	Dec 72; Mar-Apr 73	STT	NIMBUS HATCHERY, CA	1-UCA-41	104,945	6	SACRAMENTO RIVER @ BATTLE CREEK		
1972	Oct-Nov 72; Feb 73	STT	BATTLE CREEK & KESWICK	1-CM-40	300	3	RESEARCH, SIMPSON LEE CORP.		
1972	Nov 72; Jan-Mar 73	STT	BATTLE CREEK & KESWICK	1-CM-40	533,751	6-8	SACRAMENTO RIVER @ BATTLE CREEK		
1972	Jan, Mar 73	STT	BATTLE CREEK & KESWICK	1-CM-40	319,473	7-8	SACRAMENTO RIVER @ BALLS FERRY		
1972	Feb-73	STT	BATTLE CREEK & KESWICK	1-CM-40	300	6	TIBURON RESEARCH STATION		
1972	Feb-73	STT	BATTLE CREEK & KESWICK	1-CM-40	100,785	7	SACRAMENTO RIVER @ RED BLUFF		
1973	Jun-73	STT	BATTLE CREEK & KESWICK	2-CM-45	252,400	2	SACRAMENTO RIVER @ LAKE REDDING PARK		
1973	Jun-73	STT	BATTLE CREEK & KESWICK	2-CM-45	19,562	2	SACRAMENTO RIVER @ BATTLE CREEK		
1973	Jun-73	STT	BATTLE CREEK & KESWICK	2-CM-45	163,280	2	SACRAMENTO RIVER @ BALLS FERRY		
1973	May-74	KAM	COLEMAN BROODSTOCK	3-UID-47	225,310	7	SHASTA LAKE		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1973	Jul 73; May 74	KAM	COLEMAN BROODSTOCK	3-UID-47	59,443	3-5	WHISKEYTOWN LAKE		
1973	Oct-73	KAM	COLEMAN BROODSTOCK	3-UID-47	38,280	5	KESWICK RESERVOIR		
1973	Oct 73; Jan 74	KAM	COLEMAN BROODSTOCK	3-UID-47	110	5	SHASTA COLLEGE		
1973	May-74	KAM	COLEMAN BROODSTOCK	3-UID-47	13,008	8	MILITARY BASES		
1973	May-74	KAM	HOT SPRINGS HATCHERY, CA	3-UCA-46	126,653	8	SHASTA LAKE		
1973	Sep 73; Apr 74	KAM	HOT SPRINGS HATCHERY, CA	3-UCA-46	4,980	4-9	WHISKEYTOWN LAKE		
1973	Nov 73; Jan-Apr 74	KAM	HOT SPRINGS HATCHERY, CA	3-UCA-46	16,570	7	MILITARY BASES		
1973	Apr-74	KAM	HOT SPRINGS HATCHERY, CA	3-UCA-46	8,000	8	WHISKEYTOWN LAKE		
1971	Feb-74	KAM	CLARK FORK HATCHERY, ID	1-UID-34 or 3-UID-34	654	21	KESWICK RESERVOIR;		
1971	Feb-74	KAM	CLARK FORK HATCHERY, ID	1-UID-34	3	20	SHASTA COLLEGE		
1971	Jan-74	KAM	CLARK FORK HATCHERY, ID	1-UID-34	552	21	KESWICK RESERVOIR		
1971	Jun-74	KAM	CLARK FORK HATCHERY, ID	1-UID-34	2	23	SHASTA LAKE		
1974	Jun-74	KAM	CLARK FORK HATCHERY, ID	4-UID-53	264,069	3-11	SHASTA LAKE		
1972	Jul-Aug 73	RBT	ENNIS, MT	2-EN-39	38,796	9	WHISKEYTOWN RESERVOIR		
1973	Nov-73	RBT	MOUNT SHASTA HATCHERY, CA	3-UCA-48	205,530	5	SHASTA LAKE		
1973	Feb-74	STT	BATTLE CREEK & KESWICK	2-CM-45	118,475	6	SACRAMENTO RIVER @ RED BLUFF		
1973	Dec 73; Mar 74	STT	BATTLE CREEK & KESWICK	2-CM-45	258,662	6	SACRAMENTO RIVER @ BALLS FERRY		
1973	Aug 73; Apr 74	STT	BATTLE CREEK & KESWICK	2-CM-45	223,070	3-4	YUBA RIVER		
1973	Jul-Dec 73; Jan-Feb 7	STT	BATTLE CREEK & KESWICK	2-CM-45	3,075	2-4	RESEARCH, SIMPSON LEE CORP.		
1973	Aug 73; Jan-Apr 74	STT	BATTLE CREEK & KESWICK	2-CM-45	574,259	3-6	BATTLE CREEK - SACRAMENTO RIVER		
1973	Oct-73	STT	BATTLE CREEK & KESWICK	2-CM-45	500	5	TIBURON RESEARCH STA.		
1973	Mar-74	STT	BATTLE CREEK & KESWICK	2-CM-45	127,593	7	SACRAMENTO RIVER @ COLUSA		
1973	Apr-74	STT	BATTLE CREEK & KESWICK	2-CM-45	253,344	6-7	SACRAMENTO RIVER @ BUTTE CITY		
1973	Apr-74	STT	BATTLE CREEK & KESWICK	2-CM-45	102,607	7	SACRAMENTO RIVER @ PRINCETON		
1974	Mar-74	STT	BATTLE CREEK & KESWICK	3-CM-54	5,000	EYED EGGS	ARROYO GRANDE H.S.		
1973	Jun 74; Jan, Apr 75	KAM	COLEMAN BROODSTOCK	3-UID-47	600	15	SHASTA LAKE		
1973	un-Aug 74; Jan, Mar 7	KAM	COLEMAN BROODSTOCK	3-UID-47	20,375	8	WHISKEYTOWN LAKE		
1973	Feb-Mar 75	KAM	COLEMAN BROODSTOCK	3-UID-47	30	15	MILITARY BASES		
1974	Sep-74	KAM	COLEMAN BROODSTOCK	4-UID-53	50	6	SHASTA COLLEGE		
1974	Sep-74	KAM	COLEMAN BROODSTOCK	4-UID-53	106,234	5	KESWICK RESERVOIR		
1974	ov-Dec 74; Jan-May 7	KAM	COLEMAN BROODSTOCK	4-UID-53	31,198	9-11	MILITARY BASES		
1974	Apr-Jun 75	KAM	COLEMAN BROODSTOCK	4-UID-53	25,475	9-11	WHISKEYTOWN LAKE		
1974	May-75	KAM	COLEMAN BROODSTOCK	4-UID-53	477,524	8-11	SHASTA LAKE		
1975	May-75	KAM	COLEMAN BROODSTOCK	5-UID-61	354,316	2	SHASTA LAKE		
1971	Jan-75	KAM	CLARK FORK HATCHERY, ID	1-UID-34	437	25	SHASTA LAKE		
1975	Feb-75	KAM	CLARK FORK HATC[illegible]	5-UID-61	3,000	EYED EGGS	ARROYO GRANDE H.S.		
1974	Dec-75	STT	BATTLE CREEK & KESWICK	3-CM-54	101,551	7	SACRAMENTO RIVER @ BALLS FERRY		
1974	Sep-74	STT	BATTLE CREEK & KESWICK	3-CM-54	50	4	SHASTA COLLEGE		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1974	Jul-Sep 74	STT	BATTLE CREEK & KESWICK	3-CM-54	3,295	3-4	RESEARCH, SIMPSON LEE CORP.		
1974	Feb-75	STT	BATTLE CREEK & KESWICK	3-CM-54	101,334	7	SACRAMENTO RIVER @ RED BLUFF		
1974	Feb-Apr 75	STT	BATTLE CREEK & KESWICK	3-CM-54	653,317	7	BATTLE CREEK - SACRAMENTO RIVER		
1974	Mar-75	STT	BATTLE CREEK & KESWICK	3-CM-54	239,547	7	SACRAMENTO RIVER @ PRINCETON		
1974	Mar-Apr 75	STT	BATTLE CREEK & KESWICK	3-CM-54	259,461	6-7	SACRAMENTO RIVER @ ORD BEND		
1974	Mar-75	STT	BATTLE CREEK & KESWICK	3-CM-54	50,803	7	YUBA RIVER		
1975	May-75	STT	NIMBUS HATCHERY, CA	4-UCA-60	15,000	1	BATTLE CREEK - SACRAMENTO RIVER		
1974	Jul-75	KAM	COLEMAN BROODSTOCK	4-UID-53	17,710	9	WHISKEYTOWN LAKE		
1975	Oct-75	KAM	COLEMAN BROODSTOCK	5-UID-61	45	5	SHASTA COLLEGE		
1975	Sep 75; Jan-Jun 76	KAM	COLEMAN BROODSTOCK	5-UID-61	390,287	5	SHASTA LAKE		
1975	ov-Dec 75; Jan-Mar 7	KAM	COLEMAN BROODSTOCK	5-UID-61	21,064	8	MILITARY BASES		
1975	Jun-76	KAM	COLEMAN BROODSTOCK	5-UID-61	15,075	8	WHISKEYTOWN LAKE		
1975	Feb-76	KAM	COLEMAN BROODSTOCK	5-UID-61 or 5-CM-61	14,715	7	SHASTA LAKE		
1975	Apr-76	KAM	COLEMAN BROODSTOCK	5-UID-61 or 4-CM-61	5,136	8	WIHSKEYTOWN LAKE;		
1975	Apr-76	KAM	COLEMAN BROODSTOCK	5-UID-61 or 4-CM-61	9,573	8	MILITARY BASES;		
1976	Jun-76	KAM	COLEMAN BROODSTOCK	6-UID-68 or 6-CM-66	352,542	2	KESWICK RESERVOIR;		
1976	Jun-76	KAM	COLEMAN BROODSTOCK	6-CM-69	71,750	2	KESWICK RESERVOIR		
1976	Jun-76	STT	BATTLE CREEK & KESWICK	5-CM-66	48,440	2	BATTLE CREEK - SACRAMENTO RIVER		
1976	Mar-76	STT	BATTLE CREEK & KESWICK	5-CM-66	6,000	EYED EGGS	ARROYO GRANDE H.S.		
1975	Mar-76	STT	BATTLE CREEK & KESWICK	4-CM-59	53,460	7	YUBA RIVER		
1975	Oct-75	STT	BATTLE CREEK & KESWICK	4-CM-59	115,250	4	SACRAMENTO RIVER @ ANDERSON RIVER PARK		
1975	Oct-75	STT	BATTLE CREEK & KESWICK	4-CM-59	70	4	SHASTA COLLEGE		
1975	Mar-Apr 76	STT	BATTLE CREEK & KESWICK	4-CM-59	263,393	7	SACRAMENTO RIVER @ LOS MOLINOS		
1975	Feb-Mar 76	STT	NIMBUS HATCHERY, CA	4-UCA-60	156,940	7	SACRAMENTO RIVER @ LOS MOLINOS		
1976	Jul-Aug 76	KAM	COLEMAN BROODSTOCK	5-UID-61	18,095	9	WHISKEYTOWN LAKE		
1976	Dec 76; Jan 77	KAM	COLEMAN BROODSTOCK	5-UID-61	1,800	12-14	MILITARY BASES		
1976	Oct 76; May 77	KAM	COLEMAN BROODSTOCK	6-UID-68	380,311	8-9	SHASTA LAKE		
1976	Feb, Apr-May 77	KAM	COLEMAN BROODSTOCK	6-UID-68	23,334	9	MILITARY BASES		
1973	Jan-77	KAM	COLEMAN BROODSTOCK	3-UID-47	715	24	SHASTA LAKE		
1976	May-77	KAM	COLEMAN BROODSTOCK	6-UID-68	1,980	9	SHASTA COLLEGE		
1976	May-77	KAM	COLEMAN BROODSTOCK	6-CM-69	89,295	9	SHASTA LAKE		
1977	Jun-77	KAM	CLARK FORK HATCHERY, ID	7-UID-77	353,072	3	SHASTA LAKE		
1976	May-77	KAM		6-UCA-71	33,486	7	SHASTA LAKE		
1976	Apr-77	STT	BATTLE CREEK & KESWICK	5-CM-66	200,000	7	BATTLE CREEK - SACRAMENTO RIVER		
1976	Jan-Feb 77	STT	BATTLE CREEK & KESWICK	5-CM-66	241,494	8	SACRAMENTO RIVER @ TEHAMA		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1976	Nov-76	STT	BATTLE CREEK & KESWICK	5-CM-66	178,535	4-6	SACRAMENTO RIVER @ BALLS FERRY		
1976	Sep-76	STT	BATTLE CREEK & KESWICK	5-CM-66	55,600	4	SACRAMENTO RIVER @ REDDING		
1976	Jun-76	STT	BATTLE CREEK & KESWICK	5-CM-66	300	3	RESEARCH, SIMPSON LEE CORP.		
1976	Mar-Apr 77	STT	BATTLE CREEK & KESWICK	5-CM-66	477,475	6	SACRAMENTO RIVER @ WOODSON BRIDGE		
1977	Jun-77	STT	BATTLE CREEK & KESWICK	6-CM-75	540	2	RESEARCH, SIMPSON LEE CORP.		
1976	Mar-77	STT	BATTLE CREEK & KESWICK	5-CM-66	49,867	7	YUBA RIVER		
1976	Mar-77	STT	NIMBUS HATCHERY, CA	5-UCA-67	58,967	7	SACRAMENTO RIVER @ WOODSON BRIDGE		
1976	Aug-78	KAM	COLEMAN BROODSTOCK	6-UID-68	2,700	12	WHISKEYTOWN LAKE		
1976	Aug-78	KAM	COLEMAN BROODSTOCK	6-UID-68	2,170	12	CLEAR CREEK - SACRAMENTO RIVER		
1977	Mar, May 78	KAM	COLEMAN BROODSTOCK	7-UID-77	159,013	9	SHASTA LAKE		
1977	Dec 77; Feb-May 78	KAM	COLEMAN BROODSTOCK	7-UID-77	25,878	8-9	MILITARY BASES		
1977	Aug-77	KAM	COLEMAN BROODSTOCK	7-UID-77	104,570	4	KESWICK RESERVOIR LAKE		
1977	Mar-78	KAM	COLEMAN BROODSTOCK	7-UID-77	164,702	8	SHASTA LAKE		
1976	Oct-Nov 78	KAM	COLEMAN BROODSTOCK	5-UID-61	3,454	14	WHISKEYTOWN LAKE		
1977	Mar-Apr 78	STT	BATTLE CREEK & KESWICK	6-CM-75	510,806	8-10	SACRAMENTO RIVER @ LOS MOLINOS		
1977	Oct-77	STT	BATTLE CREEK & KESWICK	6-CM-75	60	5	SHASTA COLLEGE		
1977	Jul-Aug 78	STT	BATTLE CREEK & KESWICK	6-CM-75	1,200	3	RESEARCH, SIMPSON LEE CORP.		
1977	Aug-78	STT	BATTLE CREEK & KESWICK	6-CM-75	114,312	4	SACRAMENTO RIVER @ POSSE GROUNDS (REDDING)		
1977	Aug 77; Mar 78	STT	BATTLE CREEK & KESWICK	6-CM-75	106,091	4-8	YUBA RIVER		
1977	Apr-78	STT	BATTLE CREEK & KESWICK	6-CM-75	368,129	6	BATTLE CREEK - SACRAMENTO RIVER		
1977	Sep-77	STT	NIMBUS HATCHERY, CA	6-UCA-76	300	4	RESEARCH, SIMPSON LEE CORP.		
1977	Mar-78	STT	NIMBUS HATCHERY, CA	6-UCA-76	106,119	7	SACRAMENTO RIVER @ LOS MOLINOS		
1978	Mar-Apr 79	STT	MAD RIVER	7-UCA-85	374,851	5-8	SACRAMENTO RIVER @ REDDING		
1978	Aug-78	STT	MAD RIVER	7-UCA-85	400	3	RESEARCH, SIMPSON LEE CORP.		
1978	Mar, May 79	STT	MAD RIVER	7-UCA-85	500	6	TEHAMA COLUSA FISH FACILITY, SACRAMENTO RIVER		
1978	Apr-79	STT	MAD RIVER	7-UCA-85	283,652	8	SACRAMENTO RIVER @ RBDD		
1978	Jun-79	STT	MAD RIVER	7-UCA-85	13,100	9	MERCED LAKE		
1978	Feb-79	STT	SACRAMENTO RIVER @ RBDD	7-CM-80	293	7	TEHAMA COLUSA FISH FACILITY, SACRAMENTO RIVER;		
1978	Feb-79	STT	MAD RIVER	8-UCA-85 or 7-UCA-85	300	5	TEHAMA COLUSA FISH FACILITY, SACRAMENTO RIVER;		
1978	Mar-79	STT	SACRAMENTO RIVER @ RBDD	7-CM-80	200	7	TEHAMA COLUSA FISH FACILITY, SACRAMENTO RIVER		
1978	Mar-79	STT	SACRAMENTO RIVER @ RBDD	7-CM-80	132,875	6	BATTLE CREEK - SACRAMENTO RIVER		
1978	Mar-79	STT	SACRAMENTO RIVER @ RBDD	7-CM-80	133,220	7-8	SACRAMENTO RIVER @ RBDD		
1978	Jul-Aug 79	STT	MAD RIVER	7-UCA-85	46,205	8-10	MERCED LAKE		
1978	Aug-79	STT	MAD RIVER	7-UCA-85	27,270	6-7	YUBA RIVER		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1980	Jan-80	STT	BATTLE CREEK	9-CM-92 or 9-CM-93	400,050	EYED EGGS	NIMBUS HATCHERY		
1979	Apr-80	STT	BATTLE CREEK	8-CM-89	107,024	8	SACRAMENTO RIVER @ RBDD		
1979	Mar-Apr 80	STT	BATTLE CREEK	8-CM-89	445,735	8	BATTLE CREEK - SACRAMENTO RIVER		
1980	Mar-80	STT	BATTLE CREEK	9-CM-92	35,000	2	ANTELOPE CREEK - SACRAMENTO RIVER		
1980	Apr-80	STT	BATTLE CREEK	9-CM-92	629,465	2	ANTELOPE CREEK - SACRAMENTO RIVER		
1980	Jun-80	STT	BATTLE CREEK	9-CM-92	199,184	3	BATTLE CREEK - SACRAMENTO RIVER		
1980	Oct 80; Mar 81	STT	BATTLE CREEK	9-CM-92	802,268	5	BATTLE CREEK - SACRAMENTO RIVER		
1980	Feb-81	STT	BATTLE CREEK	9-CM-92	349,545	7	SACRAMENTO RIVER @ RBDD		
1981	Feb-Mar 82	STT	BATTLE CREEK	0-CM-98	268,496	7	BATTLE CREEK - SACRAMENTO RIVER		
1981	Feb-82	STT	BATTLE CREEK	0-CM-98	250	7	BODEGA MARINE LABORATORY		
1981	Mar-82	STT	BATTLE CREEK	0-CM-98	7,600	7	SACRAMENTO RIVER @ LAKE CALIFORNIA		
1981	Mar-82	STT	BATTLE CREEK	0-CM-98	50,000	7	SACRAMENTO RIVER @ RBDD		
1982	Mar-83	STT	BATTLE CREEK	2-CM-01	1,108,084	7-8	BATTLE CREEK - SACRAMENTO RIVER		
1983	Dec-83	STT	BATTLE CREEK & KESWICK	2-CM-05	248,577	7-8	SACRAMENTO RIVER @ RBDD		
1983	Jan, Mar 84	STT	BATTLE CREEK & KESWICK	2-CM-05	584,410	8	BATTLE CREEK - SACRAMENTO RIVER		
1983	Feb-Apr 84	STT	FEATHER RIVER HATCHERY, CA	2-UCA-07	158,129	7-9	SACRAMENTO RIVER @ RBDD		
1983	Apr-84	STT	FEATHER RIVER HATCHERY, CA	2-UCA-07	30,951	9	SACRAMENTO RIVER @ PRINCETON		
1983	Apr-84	STT	FEATHER RIVER HATCHERY, CA	2-UCA-07	41,171	9	BATTLE CREEK - SACRAMENTO RIVER		
1984	Jun-84	STT	NIMBUS HATCHERY, CA	3-UCA-11	232	2.5	RESEARCH, SIMPSON LEE CORP.		
198	Jun-84	STT	NIMBUS HATCHERY, CA	3-UCA-11	100	2	RESEARCH, PG&E		
1984	Jan-Feb 85	STT	BATTLE CREEK & KESWICK	3-CM-10	144,513	8-9	BATTLE CREEK - SACRAMENTO RIVER	93,066	050550, 050551, 050552, 050553, 050554, 050555, 050428, 050540, 050541, 050542, 050543
1984	Jan-85	STT	BATTLE CREEK & KESWICK	3-CM-10	130	8-9	RESEARCH, FAO - RED BLUFF		
1984	Jan-85	STT	BATTLE CREEK & KESWICK	3-CM-10	8,620	8-9	SACRAMENTO RIVER @ RBDD		
1984	Feb-85	STT	BATTLE CREEK & KESWICK	3-CM-10	135,644	7-9	SACRAMENTO RIVER @ PRINCETON	107,778	050544, 050545, 050546, 050547, 050548, 050549
1984	Jan, Mar 85	STT	NIMBUS HATCHERY, CA	3-UCA-11	198,136	6-8	BATTLE CREEK - SACRAMENTO RIVER		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases Number	Coded-wire Tagged Releases Tag Codes
1984	Jan-Mar 85	STT	NIMBUS HATCHERY, CA	3-UCA-11	107,443	8-9	SACRAMENTO RIVER @ RBDD		
1985	May-85	STT	BATTLE CREEK	5-CM-14	550	2-3	RESEARCH, SIMPSON LEE CORP.		
1985	Jun-85	STT	BATTLE CREEK	5-CM-14	104,412	2	S.FK. COW CREEK - SACRAMENTO RIVER .		
1985	Jun-85	STT	BATTLE CREEK	5-CM-14	100,005	2	CLEAR CREEK - SACRAMENTO RIVER		
1985	Jun-85	STT	BATTLE CREEK	5-CM-14	182,721	2	SACRAMENTO RIVER @ RBDD		
1986	Jun-86	STT	BATTLE CREEK	6-CM-17	86,555	6	SACRAMENTO RIVER @ BALLS FERRY		
1986	Aug-86	STT	BATTLE CREEK	6-CM-17	225,401	3	SACRAMENTO RIVER @ BALLS FERRY		
1986	May-86	STT	BATTLE CREEK	6-CM-17	80,086	3	BATTLE CREEK - SACRAMENTO RIVER		
1986	Aug-86	STT	BATTLE CREEK	6-CM-17	43,981	6	BATTLE CREEK - SACRAMENTO RIVER		
1986	Jan-86	STT	BATTLE CREEK	6-CM-17	972,072	EYED EGGS	TEHAMA-COLUSA FISH FACILITY, SACRAMENTO RIVER		
1985	May, Jul 86	STT	BATTLE CREEK	5-CM-14	500	2.5	RESEARCH, SIMPSON LEE CORP.		
1986	Oct-87	STT	BATTLE CREEK	6-CM-17	167,231	4-7	SACRAMENTO RIVER @ PRINCETON		
1986	Oct-87	STT	BATTLE CREEK	6-CM-17	9,237	6	SACRAMENTO RIVER @ WOODSON BRIDGE		
1986	Oct-87	STT	BATTLE CREEK	6-CM-17	200	7	RESEARCH, FAO - RED BLUFF		
1987	Nov-87	STT	BATTLE CREEK	7-CM-17	200	4	RESEARCH, FAO - RED BLUFF		
1987	Jun-87	STT	BATTLE CREEK	7-CM-20	600	2	RESEARCH, SIMPSON LEE CORP.		
1987	Dec-Feb 88	STT	BATTLE CREEK	7-CM-20	600,512	4-6	BATTLE CREEK - SACRAMENTO RIVER	34,703	B50404, B50415
1988	May-88	STT	BATTLE CREEK	8-CM-24	250	2-3	RESEARCH, SIMPSON LEE CORP.		
1988	Jan-89	STT	BATTLE CREEK	8-CM-24	590,741	7-9	BATTLE CREEK - SACRAMENTO RIVER		
1988	Jan-89	STT	BATTLE CREEK	8-CM-24	100	8-9	RESEARCH, FAO - RED BLUFF		
1988	Jan-89	STT	BATTLE CREEK	8-CM-27	29,730	5	BATTLE CREEK - SACRAMENTO RIVER		
1988	Feb-89	STT	BATTLE CREEK	8-CM-25	134,000	5	BATTLE CREEK - SACRAMENTO RIVER		
1989	Feb-90	STT	FEATHER RIVER HATCHERY, CA	SBW-89-CA	29,400	8	BATTLE CREEK - SACRAMENTO RIVER;		
1989	Feb-Mar 90	STT	BATTLE CREEK	SBW-89-COL	41,994	11	BATTLE CREEK - SACRAMENTO RIVER;	27,393	0501010109
1989	Feb-90	STT	BATTLE CREEK	BCW-89-COL	2,848	11	BATTLE CREEK - SACRAMENTO RIVER:		
1990	Jan-90	STT	BATTLE CREEK	SBW-90-COL	463,5[illegible]	EYED EGGS	MOKELUMNE HATCHERY		
1990	Aug-90	STT	BATTLE CREEK	SBW-90-COL	421,769	4-5	FEATHER RIVER @ YUBA CITY		
1990	Aug-90	STT	BATTLE CREEK	SBW-90-COL	151,470	4-5	FEATHER RIVER HATCHERY		
1990	Jan-Feb 91	STT	BATTLE CREEK	SBW-90-COL	698,847	10	BATTLE CREEK - SACRAMENTO RIVER		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	97,066	3	CLEAR CREEK @ WHISKEYTOWN		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	103,728	3	CLEAR CREEK - WHISKEYTOWN		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	25,113	3	CLOVER CREEK - SACRAMENTO RIVER		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	24,991	3	S.FK. COW CREEK - SACRAMENTO RIVER		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	24,870	3	OLD COW CREEK - SACRAMENTO RIVER		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	24,991	3	OAK RUN CREEK - SACRAMENTO RIVER		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	31,057	3	SACRAMENTO RIVER ABOVE INTAKE #3		
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	51,430	3	BATTLE CREEK @ JELLY'S FERRY BRIDGE		

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Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1991	Jun-91	STT	BATTLE CREEK	SBW-91-COL	1,091	3	GLEN-COLUSA IRRIGATION DISTRICT		
1991	Jan-Feb 92	STT	BATTLE CREEK	SBW-91-COL	747,014	6-10	SACRAMENTO RIVER @ BATTLE CREEK;	202441	050101011, 050101030, 052059, 052060
1991	Jan-92	STT	BATTLE CREEK	SBW-91-COL	148,009	6-9	BATTLE CREEK @ HATCHERY		
1992	Jan-93	STT	BATTLE CREEK	SBW-92-COL	107,229	7-9	BATTLE CREEK @ SACRAMENTO RIVER	105,141	052741, 052743
1992	Mar-93	STT	BATTL E CREEK	SBW-92-COL	147,713	9-11	BATTLE CREEK @ HATCHERY	110,832	052742, 052744
1992	Jan-93	STT	BATTLE CREEK	SBW-92-COL	640,988	7-9	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP		
1993	May-93	STT	BATTLE CREEK	SRW-93-COL	19,886	1.8	GLEN-COLUSA IRRIGATION DISTRICT		
1993	May-93	STT	BATTLE CREEK	SRW-93-COL	198,217	2.4	CLEAR CREEK - SACRAMENTO RIVER		
1993	May-93	STT	BATTLE CREEK	SRW-93-COL	198,120	2.1-2.3	S. FK. BATTLE CREEK - SACRAMENTO RIVER		
1993	May-93	STT	BATTLE CREEK	SRW-93-COL	99,990	2.0-2.1	S. FK. COW CREEK - SACRAMENTO RIVER		
1993	Jun-93	STT	BATTLE CREEK	SRW-93-COL	5,109	3.0	RESEARCH, FRO - RED BLUFF		
1993	Jan-94	STT	BATTLE CREEK	SBW-93-COL	604,570	8-9	SACRAMENTO RIVER @ BALLS FERRY	213,366	053312, 053313, 053314, 053315
1993	Feb-94	STT	BATTLE CREEK	SBW-93-COL	151,538	8-9	BATTLE CREEK @ HATCHERY		
1994	May-Jun 94	STT	BATTLE CREEK	SBW-94-COL	267,718	2-3	SACRAMENTO RIVER @ BATTLE CREEK		
1994	May-Jun 94	STT	BATTLE CREEK	SBW-94-COL	203,772	2.5	COW CREEK - SACRAMENTO RIVER		
1994	Jun-94	STT	BATTLE CREEK	SBW-94-COL	100,286	2.5	CLEAR CREEK - SACRAMENTO RIVER		
1994	Aug-94	STT	BATTLE CREEK	SBW-94-COL	516	4.3	RESEARCH, FRO - RED BLUFF		
1994	Jan-95	STT	BATTLE CREEK	SBW-94-COL	385,322	7-8.5	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP	236,866	053544, 053545, 053547, 064519, 064520
1994	Jan-95	STT	BATTLE CREEK	SBW-94-COL	316,535	8.5-9.0	BATTLE CREEK - SACRAMENTO RIVER		
1995	May-95	STT	BATTLE CREEK	SBW-95-COL	232,758	2.5	CLEAR CREEK - SACRAMENTO RIVER		
1995	Jun-95	STT	BATTLE CREEK	SBW-95-COL	208,021	2.3	COW CREEK - SACRAMENTO RIVER		
1995	Jun-95	STT	BATTLE CREEK	SBW-95-COL	67,372	2.5	S. FK. BATTLE CREEK - SACRAMENTO RIVER		
1995	Jun-95	STT	BATTLE CREEK	SBW-95-COL	68,122	3.0	SACRAMENTO RIVER @ RBDD		
1995	Jan-96	STT	BATTLE CREEK	SBW-95-COL	380,993	9.0	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP	125,764	053744, 053745
1995	Jan-96	STT	BATTLE CREEK	SBW-95-COL	150,141	9.0	BATTLE CREEK - SACRAMENTO RIVER		
1996	May-96	STT	BATTLE CREEK	SRW-96-COL	105,230	2.3	S.FK. BATTLE CREEK - SACRAMENTO RIVER		
1996	May-96	STT	BATTLE CREEK	SRW-96-COL	101,355	2.3	N. FK. BATTLE CREEK - SACRAMENTO RIVER		
1996	Jun-96	STT	BATTLE CREEK	SBW-96-COL	102,585	2.5-3.0	S. FK. COW CREEK - SACRAMENTO RIVER		
1996	Jun-96	STT	BATTLE CREEK	SBW-96-COL	90,158	3.0	N. FK. COW CREEK - SACRAMENTO RIVER		

Appendix 10B. Broodstock source and distribution summary of steelhead and non-anadromous rainbow trout at Coleman National Fish Hatchery. STT, RBT, and KAM denote steelhead trout, non-anadromous rainbow trout, and Kamloops (Gerrard strain rainbow trout), respectively.

Brood Year	Release Date	Stock	Source of Eggs or Brood Stock	Lot Number	Number Released	Approx. Size (in.)	Release Location	Coded-wire Tagged Releases	
								Number	Tag Codes
1996	Jan-97	STT	BATTLE CREEK	SBW-96-COL	540,267	9.0	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP		
1997	Mar-97	STT	BATTLE CREEK	SBW-97-COL	100	1.0-1.4	MISC RESEARCH/ERS		
1997	May-97	STT	BATTLE CREEK	SBW-97-COL	100	1.8	MISC RESEARCH/ERS		
1997	Jun-97	STT	BATTLE CREEK	SBW-97-COL	81,585	2.8-3.2	N. FK. BATTLE CREEK - SACRAMENTO RIVER		
1997	Jun-97	STT	BATTLE CREEK	SBW-97-COL	35,849	3.0	S. FK. BATTLE CREEK - SACRAMENTO RIVER		
1997	Jan-98	STT	BATTLE CREEK	SBW-97-COL	401,062	8.8-9.0	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP		
1997	Jan-98	STT	BATTLE CREEK	SBW-97-COL	143,517	8.7	BATTLE CREEK - SACRAMENTO RIVER		
1998	Jun-98	STT	BATTLE CREEK	SBW-98-COL	49,928	2.4	N. FK. BATTLE CREEK - SACRAMENTO RIVER		
1998	Jan-99	STT	BATTLE CREEK	SBW-98-COL	366,061	8.4-8.7	SACRAMENTO RIVER @ BALLS FERRY BOAT RAMP		
1998	Jan-99	STT	BATTLE CREEK	SBW-98-COL	130,444	7.5	BATTLE CREEK - SACRAMENTO RIVER		
1999	Aug-99	STT	BATTLE CREEK	SBW-99-COL	1,297	3.8	RESEARCH-UC DAVIS		
1999	Jan-00	STT	BATTLE CREEK	SBW-99-COL	389,673	8.7-9.0	SACRAMENTO RIVER @ BEND BRIDGE	146,913	055127, 055128, 054136
1999	Jan-00	STT	BATTLE CREEK	SBW-99-COL	130,250	9.0	BATTLE CREEK-SACRAMENTO RIVER		
1999	Jan-00	STT	BATTLE CREEK	SBW-99-COL	12	8.8	SHASTA WILDLIFE REFUGE		

Appendix 10C. Analysis of rates of straying by chinook salmon released from Coleman National Fish Hatchery

Abstract

We analyzed and compared contribution information for groups of Coleman National Fish Hatchery (NFH) juveniles released at various off-site locations to groups released on-site (i.e, released directly into Battle Creek at Coleman NFH) to develop estimates of stray indices. These stray indices can be used to estimate the potential genetic impact of off-site releases. The larger the stray index, the greater the potential for straying. We assume that increased straying leads to a greater potential for loss of between-population genetic diversity by interbreeding with distant or natural populations of salmon in the Sacramento River and elsewhere.

Evidence is presented to show that: 1) off-site releases may disrupt the imprinting cycle; 2) straying by juveniles released off-site can be substantial (70-90%); and, 3) straying typically increases as the distance from the hatchery to the off-site release location is increased. Furthermore, previous investigations by the Service's RBFWO show that the geographic distribution of straying increased as the distance to off-site release locations increases (USFWS 1996a).

Current practice at Coleman NFH calls for conducting general production releases of chinook salmon and steelhead trout directly into Battle Creek, or in close proximity to Battle Creek in the upper Sacramento River watershed. Because fish at Coleman NFH are released close to the location of rearing, we conclude that impacts from straying are minimal. Further, since all stocks propagated at Coleman and Livingston Stone NFH's are integrated with the ESU's of the natural stocks in Battle Creek and/or the upper Sacramento River, we conclude genetic impacts from inherent (i.e., background) stray rates are likely minimal.

Introduction

General Information on Imprinting and Straying

Most salmon imprint and return to the stream of origin, but some do not and are considered strays. Instead of returning to their natal stream, some returning fish "stray" and spawn elsewhere (Quinn 1993 in Griffith et al. 1999). Hasler and Scholz (1983) state that straying occurs in natural populations to provide an insurance policy against loss of an entire stock due to a catastrophe in the home stream, and to colonize new habitat. Straying in natural stocks can also maintain gene flow reducing problems associated with inbreeding (Hasler and Scholz 1983), and straying promotes genetic heterogeneity at the population level (Utter 1991).

Most literature suggests that adult salmon home to the river or stream of origin based on olfactory cues acquired as juvenile salmonids during their fresh water residence and downstream migration (Hasler and Scholz 1983, Healey 1991, Dittman et al. 1996). The particular odor a salmon imprints upon is likely derived from the soils and vegetation of a particular stream (Hasler and Scholz 1983). Although salmon are believed to imprint upon a stream based on olfactory cues learned as a juvenile, evidence also suggests a genetic component in homing (Labelle 1992, McIsaac and Quinn 1988, Bams 1976, Hard and Heard 1999). All investigators give evidence suggesting locally-adapted salmon home better to their river of origin than to another river, or they home at higher rates than introduced populations.

The degree of imprinting is likely related to the timing and amount of exposure in a particular water source; however, the critical time period and extent of exposure necessary are largely unknown. Pascual et al. (1995) suggested that three interacting variables characterize the process of emigration and determine the occurrence of imprinting: fish location, the physiological state of the fish, and the time at which the fish experience given locations. A review of available literature suggest that imprinting to the natal stream can occur at various life stages for different Pacific salmonids. Tilson et al. (1994) found that chemical imprinting in kokanee (*O. nerka*) salmon occurred during elevated thyroxine levels; and two sensitive (or critical) periods for chemical imprinting were the alevin/swim-up and smolt stages. Unwin and Quinn (1993) hypothesized that salmon imprint during two distinct stages, emergence and transition to saltwater. Odors learned during entry to the ocean provided initial cues for identification of the home river and odors learned at emergence provided cues for a more specific location in the home river (Unwin and Quinn 1993). Coho (*O. kisutch*) salmon are believed to imprint as smolts, approximately 16 to 18 months after hatching (Hasler and Scholz 1983). Bjornn et al. (1981) theorized that salmon smolts receive imprinting stimuli once they actually commence downstream movement.

Different runs of chinook salmon may also imprint at different times. Brannon (1981) concluded that imprint must occur very early for those populations that commence downstream movement soon after emergence, such as pink and chum salmon. In describing typical stream-type chinook salmon (spring run) and ocean-type chinook salmon (fall run), Healey (1991) stated ocean-type chinook may imprint very early while stream-type may delay imprinting until just prior to ocean migration. Imprinting of Sacramento River fall and winter chinook salmon likely occurs at an early life stage. Newly emergent winter chinook salmon fry (33-40 mm) are routinely captured in rotary screw traps at the RBDD (RM 243) (Service, Red Bluff Fish and Wildlife Office [RBFWO], Red Bluff, California, unpublished data). This location is approximately 90 km downstream from the principle spawning area for winter chinook salmon, generally described as Deshutes Road Bridge (RK 450) upstream to Anderson Cottonwood Irrigation District diversion dam (RM 297; Frank Fisher, CDFG [retired], Red Bluff, California, personal communication).

Introduction: Objective

A disruption in outmigration appears to affect homing and straying. Hansen et al. (1989 in Wunderlich and Pantaleo 1995) suggest that releasing juvenile salmon from locations other than the original rearing site can break one or more links in the imprinting sequence, and therefore increase straying. Pacific salmon released directly from the rearing site generally result in little to no measurable straying among returning adults. However releases at locations other than the rearing site generally have higher straying rates than releases directly from the rearing site (Lister et al. 1981, Dettman and Kelley 1987, Cramer 1991). Lister et al. (1981) also concluded that the farther the release site is from the hatchery, the lower the homing rate back to the hatchery, consequently, resulting in a higher straying rate.

In the following analysis, we examine escapement and ocean contribution data for releases of Coleman NFH fall and late-fall chinook salmon to determine the effect of off-site releases on the homing ability of these stocks. In comparison to groups released directly at Coleman NFH (i.e., into Battle Creek) stray indices for various off-site release groups are developed as a measure of imprint disruption. This measure is also used to estimate the potential for genetic impacts associated with loss of between-population genetic diversity resulting from the interbreeding of strays from these release groups with distant natural populations of salmon in the Sacramento/San Joaquin River system.

Methods

Initial Analysis

To begin the analysis, we examined coded-wire recovery information from the Pacific States Marine Fisheries Commission's website (http://www.rmis.org/index.html) and included recoveries from Battle Creek sampling efforts (Returns to Coleman NFH expanded to estimate tag returns in lower Battle Creek) to look for differences in catch rates.

We defined *Catch Rate* as follows:

$$\text{Catch Rate} = \frac{\text{Ocean Harvest}}{\text{Ocean Harvest} + \text{Hatchery Returns} + \text{Battle Creek Escapement}}$$

This calculation is similar to the that used by the Pacific Fishery Management Council (1998) to generate the Central Valley Harvest Index, an index of annual stock abundance.

We defined *Contribution Rate* as follows:

$$\text{Contribution Rate} = \frac{\text{Number Coded - Wire Tag Recoveries for a Group}}{\text{Number Tagged Fish Released in the Group}}$$

The Contribution Rate can be considered an index of survival for individual release groups.

We assumed that: 1) all fish within a single release group would be equally vulnerable in regards to ocean harvest and collection at the hatchery; and, 2) multiple release groups within the same brood year should generally result in similar catch rates, independent of ocean contribution rates. This second assumption is demonstrated empirically in Figure 10C-1 by plotting the relationship between Ocean Contribution Rate and Catch Rate for ten groups of late-fall chinook salmon released from Coleman NFH in 1993. Although Ocean Contribution Rates are highly variable (Average=0.35, SE=0.23, Range: 0.2 - 0.6) among the ten release groups, Catch Rates are considerably more stable (Average=69.1, SE=0.50, Range: 63.6 - 75.5). Catch rates tend to be similar for all groups of fish released within a brood year because contribution (ocean catch and freshwater returns) is generally dominated by three year-olds. For example, approximately 80% of fall chinook salmon from Coleman NFH are harvested, or return to spawn, at age-3. Although each brood year contributes over multiple age classes, 3 year-olds are largely responsible for influencing catch rates.

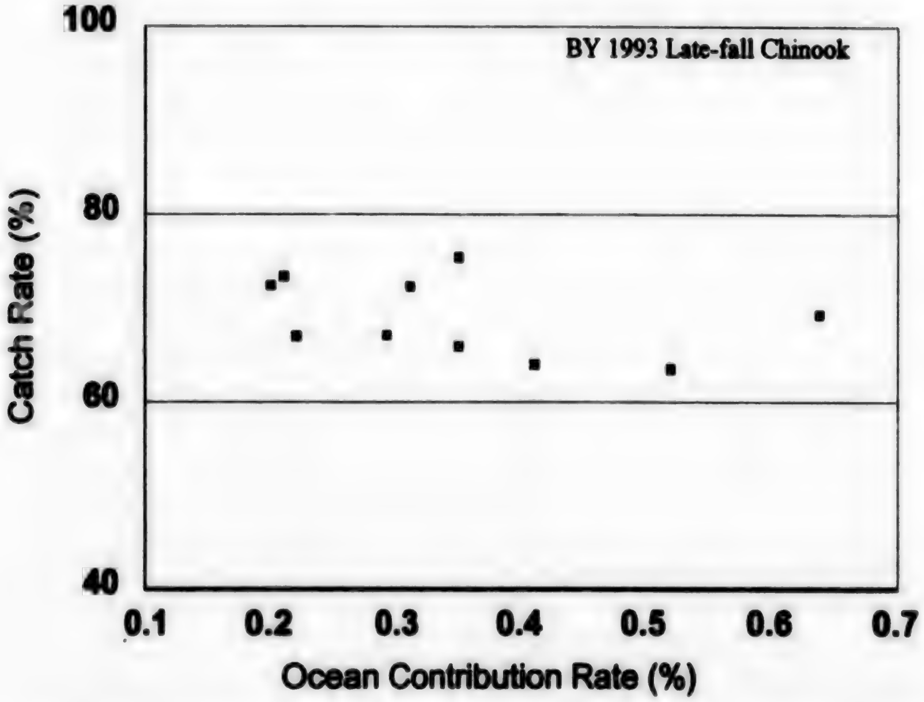

Figure 10C-1. Relationship between catch rate and ocean contribution rate (an index of survival) for 10 groups of brood year (BY) 1993 late-fall chinook salmon.

Comparison of catch rates for groups released on-site to groups released off-site showed a consistent and peculiar trend, in that groups of fish released a greater distance from the hatchery seemed to be associated with higher catch rates (Figures 10C-2 through 10C-4). This relationship between catch rate and distance to the release site appears to suggest that location of release of juvenile salmon has a direct effect on vulnerability (catchability) of adults two years hence. We do not believe that vulnerability to fishing gear is influenced by release site, rather, as stated above, ocean catch rates for various release groups are likely influenced by relative abundance in the ocean. Therefore, we assume that ocean harvest rates should be similar for all groups within a brood year, because all groups would be subjected to equal harvest effort at age-3. We assert the difference exhibited in the catch rate is instead due to an underestimate of freshwater returns, and that adults resulting from off-site releases (see Figure 10C-5 for locations of release sites) are more likely to return to freshwater locations other than Battle Creek (i.e., stray) due to the disruption in the imprinting cycle.

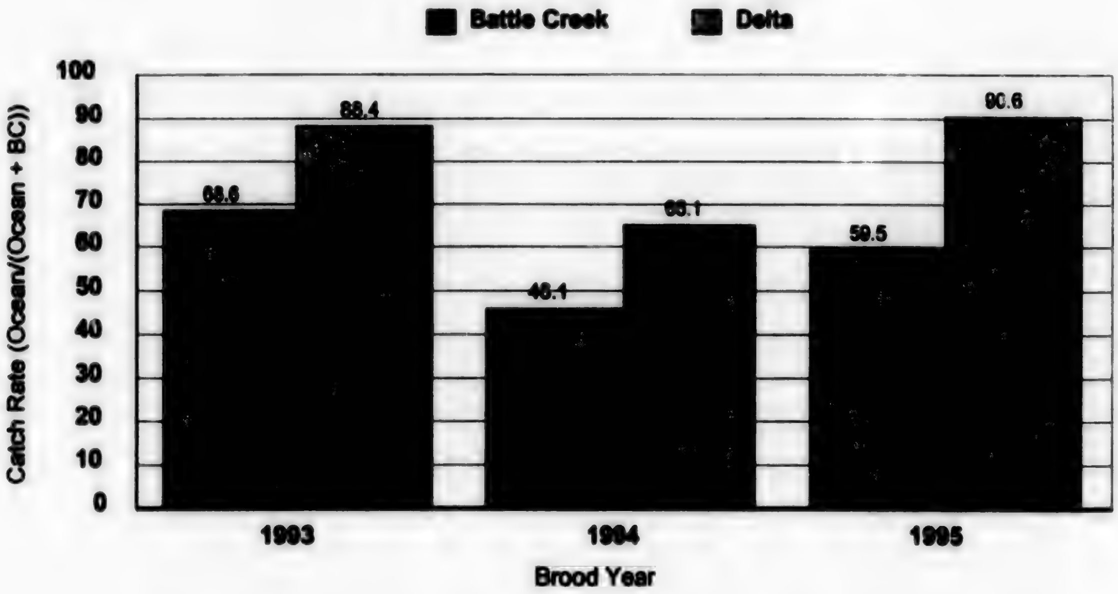

Figure 10C-2. Comparisons of brood years 1993 - 1995 late-fall chinook salmon juveniles released into Battle Creek and at various locations within the Delta. Note the general trend of higher catch rates associated with off-site release groups.

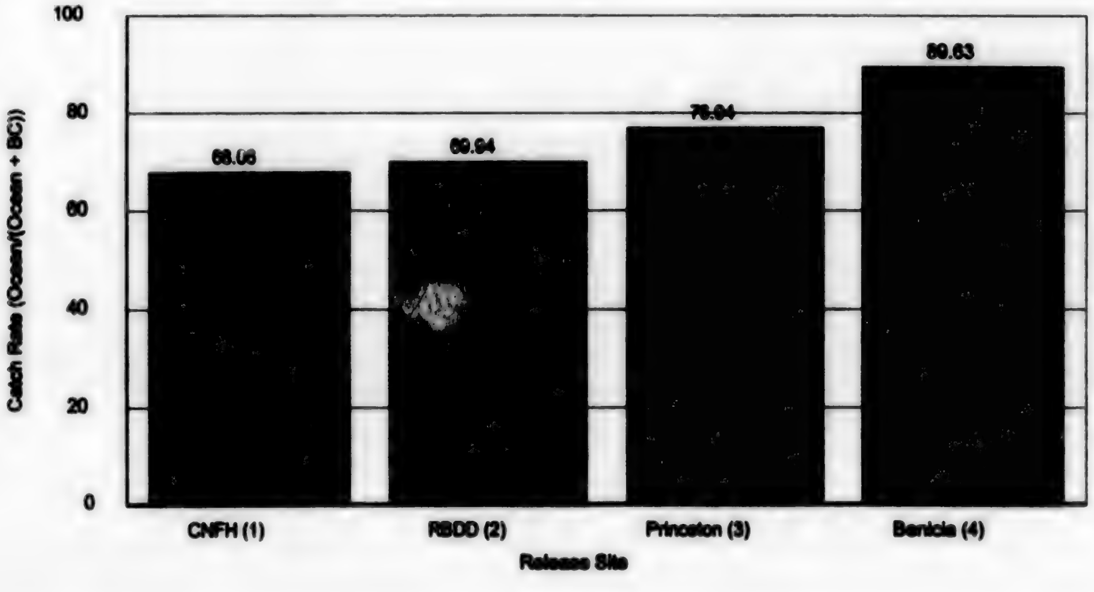

Figure 10C-3. Composite comparisons of brood year 1988 - 1992 fall chinook salmon juveniles released into Battle Creek at Coleman National Fish Hatchery (NFH) and at various downstream locations in the Sacramento River, California. Release sites are ranked according to increasing distance from Coleman NFH (1 = closest, 4 = farthest). and rates due to unaccounted for strays (i.e., adults not returning to the Battle Creek watershed).

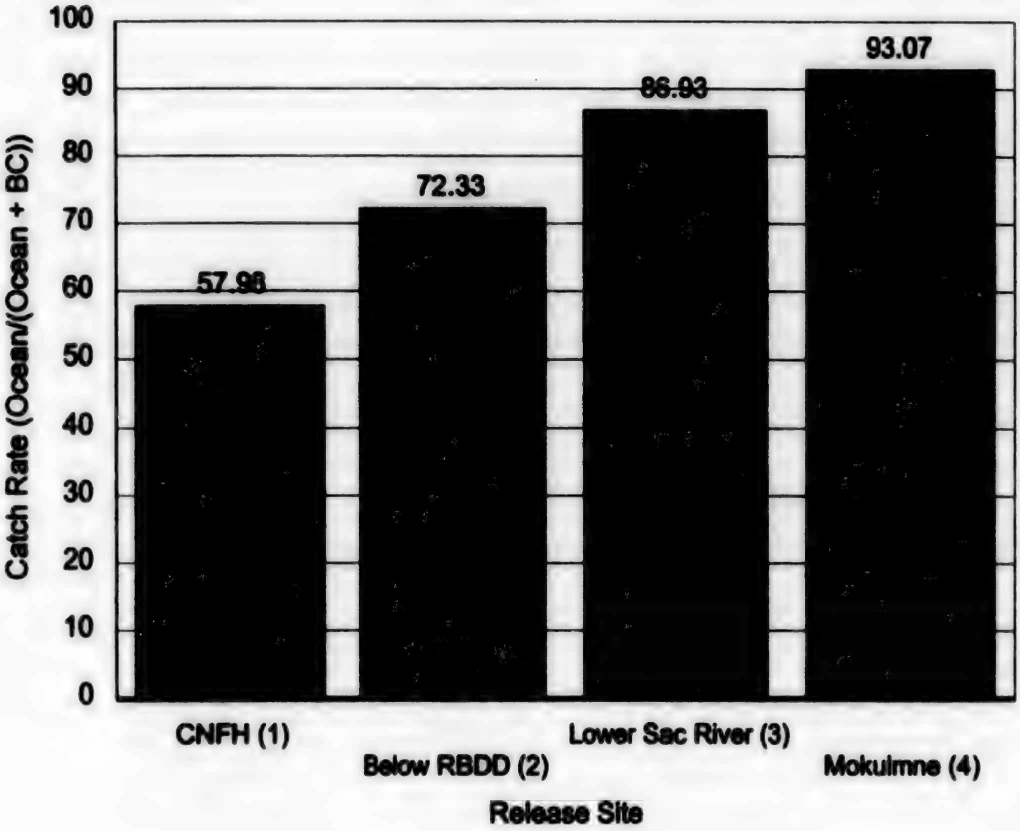

Figure 10C-4. Comparison of brood year 1981 - 1987 fall chinook salmon fry released into Battle Creek at Coleman National Fish Hatchery (NFH) and at various downstream locations in the Sacramento River, California. Release sites are ranked according to increasing distance from Coleman NFH (1 = closest, 4 = farthest). Note the general trend of higher catch rates associated with increased distance between rearing and release locations. We believe the difference is not due to predisposed differential fishing vulnerability, but instead is a result of underestimating freshwater escapement numbers and rates due to unaccounted for strays (i.e., adults not returning to the Battle Creek watershed).

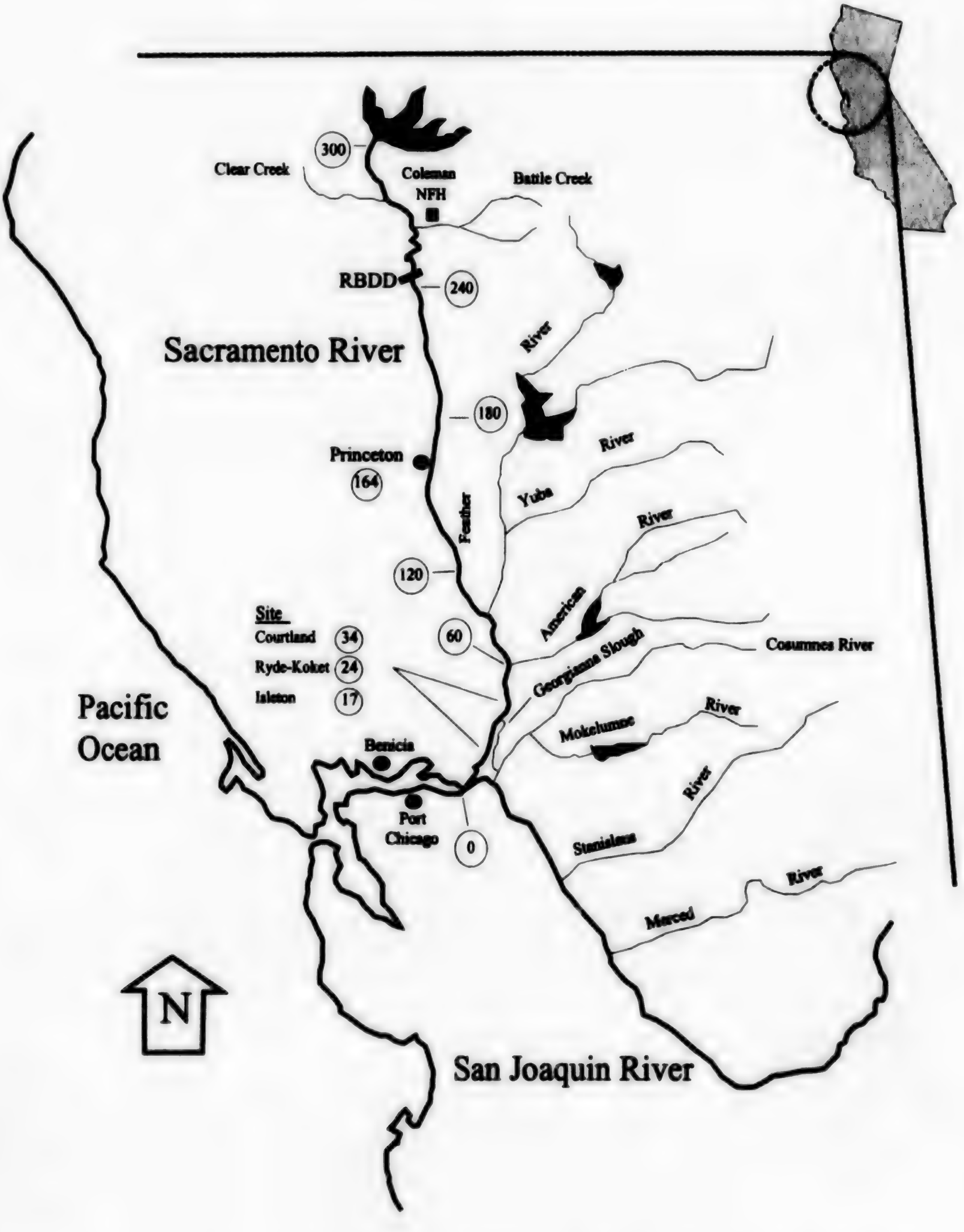

Figure 10C-5. Map of selected water ways in California's Central Valley and release locations for chinook salmon produced at Coleman National Fish Hatchery (NFH). Approximate river miles are indicated within circles.

Stray Rate Analysis
If unaccounted freshwater returns (strays) were included in the denominator of the catch rate equation for off-site release groups, catch rates would become more equitable. Equalizing the catch rates of off-site releases to those of on-site releases provides a means to estimate the number of strays and stray rates for the off-site release groups (alternatively, Escapement:Harvest ratios for on-site releases could be equalized to Escapement:Harvest ratios for off-site releases). Catch rates and Escapement:Harvest ratios were generated for groups of fall and late-fall chinook salmon released directly at the hatchery. The overall Catch Rate for on-site releases was used as the benchmark value to which we compared Catch Rates for off-site releases to generate stray indices. Using Catch Rates of on-site release groups to generate the stray index was considered appropriate because on-site releases (especially for smolts) are a recognized as having high fidelity to their natal location when they return as adults. An index was generated to estimate straying occurring as a result of off-site releases.

The following series of formulae were used to correct the Escapement:Harvest ratios of off-site release groups to generate the number of unaccounted for strays and stray index.

(Equation 1) **Escapement:Harvest Ratio= (BC/O)**
Where:
BC = Returns to Battle Creek which includes Coleman NFH recoveries and expanded numbers from Battle Creek run-size estimates.
O = Ocean recoveries

We assume:
(Equation 2) **BC/O(onsite)=BC/O(offsite)**

Given: 1) Marked fish were harvested relative to their abundance in the ocean;
2) Ocean mortality rates were similar among release groups; and,
3) All marked fish released in Battle Creek homed correctly (i.e., stray rate = 0)

Where:
(Equation 3) **BC/O(on-site)≠BC/O(off-site), the difference is due to "strays."**

Therefore:
(Equation 4) **BC/O(on-site)=(BC+*S*)/O(off-site)**

Solving for *S*:
(Equation 5) ***S*=BC/O(on-site) * O(off-site) - BC(off-site)**

Estimating the number of strays allows the generation of a stray index that can be used as an estimate of the stray rate. The value is only an index, as it does not provide an estimate of straying from the onsite release group.

(Equation 6) Stray Index/Rate Estimate (offsite) = $S/(S+BC(\text{offsite}))$

Results

Late-fall Chinook Salmon

Brood years 1993 through 1995 were used in the analysis of straying of late-fall chinook salmon using the same methodology described above. Beginning with brood year 1993, requests have been made by the Interagency Ecological Program (IEP), and the various participating agencies (NMFS, CDFG, DWR, USFWS) for Coleman NFH to provide late-fall chinook salmon for releases into the interior Delta (Georgianna Slough), and various downstream control sites (i.e., Ryde, Isleton, Courtland, Port Chicago). The release groups have been requested as surrogates for winter chinook salmon and to evaluate and model modifications to Delta operations as to their potential effects (positive/negative).

In this straying analysis, indices of straying were generated for the releases made into the Delta and other downstream locations. Delta and downstream release sites generated relatively large stray indices of 71.4%, 54.3%, and 84.7% for brood years 1993 through 1995 respectively (Table 10C-1). For these brood years, multiple release groups for both on-site and downstream/ Delta locations were made, making this analysis more representative and likely more powerful than the analysis conducted with fall chinook salmon (see below). These data suggest that between approximately 54 and 84% of adults resulting from groups of juveniles released into the Delta strayed to freshwater locations other than Battle Creek. In fact, coded-wire tagged adults from these release groups have been noted in the American River at Nimbus Hatchery (Alan Baracco, CDFG, personal communication).

Fall Chinook Salmon

Applying the methodology described above, we separated historical fry releases (brood years 1980 - 1987) from smolt releases (brood years 1980 -1986). Additional analyses were also conducted for smolt releases during brood years 1987 through 1991. Stray indices generated for off-site release groups in those years are shown in Tables 10C-2 through 10C-4 and summarized in Table 10C-5.

Table 10C-1. Stray indices and catch rates for brood years 1993 - 1995 Coleman National Fish Hatchery late-fall chinook salmon smolts released directly into Battle Creek at the hatchery and at various downstream/Delta locations.

Broodyear	Run	Tag Code	Release Location	Number	Ocean (O)	BC Returns (BC)	Catch Rate (%)	Ratio (BC/O)	Estimated Strays	Stray Index (%)
1993	Late-Fall	053316	Battle Creek	52985	273	156	63.6	0.57		
	Late-Fall	053317	Battle Creek	53464	114	41	73.5	0.36		
	Late-Fall	053408	Battle Creek	67645	237	122	66.0	0.51		
	Late-Fall	053409	Battle Creek	72236	213	104	67.2	0.49		
	Late-Fall	053410	Battle Creek	73862	145	55	72.5	0.38		
	Late-Fall	053411	Battle Creek	68848	151	74	67.1	0.49		
	Late-Fall	053412	Battle Creek	69894	218	83	72.4	0.38		
	Late-Fall	053413	Battle Creek	73220	466	206	69.3	0.44		
	Late-Fall	053414	Battle Creek	65609	228	74	75.5	0.32		
	Late-Fall	053415	Battle Creek	54248	220	123	64.1	0.56		
				Total	**2265**	**1038**	**68.6**	**0.46**	**0**	**0.0**
	Late-Fall	064521	Georgianna Slough	34650	79	12	86.8	0.15		
	Late-Fall	064522	Ryde-Koket	33668	287	36	88.9	0.13		
				Total	**366**	**48**	**88.4**	**0.13**	**120**	**71.4**
1994	Late-Fall	053546	Battle Creek	56340	244	367	39.9	1.50		
	Late-Fall	053620	Battle Creek	125754	1716	2463	41.1	1.44		
	Late-Fall	053621	Battle Creek	128159	1293	980	56.9	0.76		
				Total	**3253**	**3810**	**46.1**	**1.17**	**0**	**0.0**
	Late-Fall	053425	Georgianna Slough	31532	11	8	57.9	0.73		
	Late-Fall	053426	Isleton	30220	28	13	68.3	0.46		
	Late-Fall	062525	Georgianna Slough	31328	100	53	65.4	0.53		
	Late-Fall	062524	Isleton	31557	257	138	65.1	0.54		
				Total	**396**	**212**	**65.1**	**0.54**	**252**	**54.3**
1995	Late-Fall	053416	Battle Creek	59136	257	160	61.6	0.62		
	Late-Fall	053618	Battle Creek	129897	1120	731	60.5	0.65		
	Late-Fall	054118	Battle Creek	60385	302	110	73.3	0.36		
	Late-Fall	054117	Battle Creek	67185	665	501	57.0	0.75		
	Late-Fall	054108	Battle Creek	68104	471	414	53.2	0.88		
				Total	**2815**	**1916**	**59.5**	**0.68**	**0**	**0.0**
	Late-Fall	054112	Courtland	34122	228	22	91.2	0.10		
	Late-Fall	054113	Georgianna Slough	33670	148	9	94.3	0.06		
	Late-Fall	054114	Ryde-Koket	30281	242	23	91.3	0.10		
	Late-Fall	054111	Port Chicago	34596	264	38	87.4	0.14		
				Total	**882**	**92**	**90.6**	**0.10**	**508**	**84.7**

Table 10C-2. Stray indices and catch rates for Coleman National Fish Hatchery fall chinook fry released at various locations, brood years 1980 - 1987. Returns to Battle Creek include both adults recovered at the hatchery and expanded recoveries for lower Battle Creek returns.

Brood Year	Run	Tag Code	Size in.	Size #/lb	Release Location	Number	Ocean (O)	BC Returns (BC)	Catch Rate (%)	Ratio (BC/O)	stimated Strays	Stray Index (%)	Actual Strays Recovered
1985	Fall	H50707		341	CNFH	51,371	226	185	54.99	0.82			0
1986	Fall	B50413		203	CNFH	51,075	82	38	68.33	0.46			0
1987	Fall	B50206		457	CNFH	48,299	19	14	57.58	0.74			0
					Total		**327**	**237**	**57.98**	**0.72**	**0**	**0.0%**	0
1980	Fall	H60101	2	537	Below RBDD	35,905	42	27	60.87	0.64			1
1980	Fall	H60105	2	537	Below RBDD	47,019	64	24	72.73	0.38			0
1981	Fall	H60202	2	502	Below RBDD	41,753	115	93	55.29	0.81			7
1981	Fall	H60206	2	502	Below RBDD	43,673	118	67	63.78	0.57			3
1983	Fall	H60404	2	447	Below RBDD	43,883	124	28	81.58	0.23			0
1983	Fall	H60504	2	447	Below RBDD	47,855	234	90	72.22	0.38			1
1984	Fall	H60505	2	401	Below RBDD	49,155	74	20	78.72	0.27			0
1984	Fall	H60605	2.5	370	Below RBDD	52,313	198	16	92.52	0.08			0
1985	Fall	H60705		330	Below RBDD	51,426	419	150	73.64	0.36			0
1986	Fall	H60707		310	Below RBDD	52,977	115	65	63.89	0.57			0
1987	Fall	B61401		350	RBDD	48,280	120	41	74.53	0.34			7
					Total		**1623**	**621**	**72.33**	**0.38**	**555**	**47.2%**	19
1983	Fall	H60405	2	445	Courtland	48,460	61	11	84.72	0.18			3
1983	Fall	H60503	2	445	Courtland	48,157	178	31	85.17	0.17			2
1984	Fall	H60506	2	361	Courtland	51,201	102	8	92.73	0.08			0
1984	Fall	H60604	2	382	Courtland	51,985	89	14	86.41	0.16			0
1985	Fall	H60607		445	Courtland	50,961	22	6	78.57	0.27			2
1985	Fall	H60703		337	Courtland	53,831	86	10	89.58	0.12			6
1986	Fall	H60706		339	Courtland	48,733	28	3	90.32	0.11			0
1981	Fall	H60203	2	498	Isleton	43,248	31	6	83.78	0.19			5
1981	Fall	H60207	2	500	Isleton	40,508	12	0	100.00	0.00			1
1983	Fall	H60406	2	444	Ryde-Koket	43,465	82	18	82.00	0.22			6
1983	Fall	H60502	2	444	Ryde-Koket	46,767	142	12	92.21	0.08			8
1984	Fall	H60507	2	404	Ryde-Koket	49,183	83	4	95.40	0.05			0
1984	Fall	H60603	2	389	Ryde-Koket	50,550	98	9	91.59	0.09			0
1985	Fall	H60702		343	Ryde-Koket	52,635	83	23	78.30	0.28			3
1985	Fall	H60704		343	Ryde-Koket	52,748	127	29	81.41	0.23			0
					Total		**1224**	**184**	**86.93**	**0.15**	**703**	**79.3%**	36
1980	Fall	H60107	2	599	Mokelumne R., mouth	45,796	38	0	100.00	0.00			1
1983	Fall	H60407	2	452	North Fork Mokelumne	42,165	61	2	96.83	0.03			0
1983	Fall	H60501	2	454	South Fork Mokelumn	45,036	39	0	100.00	0.00			7
1984	Fall	H60601	2.5	370	South Fork Mokelumn	50,052	69	10	87.34	0.14			3
1984	Fall	H60602	2	421	North Fork Mokelumne	51,145	77	9	89.53	0.12			0
					Total		**282**	**21**	**93.07**	**0.07**	**183**	**89.7%**	11

Table 10C-3. Stray indices and catch rates for general production groups of Coleman National Fish Hatchery fall chinook salmon smolts released into Battle Creek at the hatchery, and at the Red Bluff Diversion Dam (brood years 1980 - 1986).

Brood Year	Run	Tag Code	#/lb	Release Location	Number	Ocean (O)	BC Returns[a] (BC)	Catch Rate (%)	Ratio (BC/O)	Actual Strays Recovered	Estimated Strays	Stray Index
1980	Fall	066016	110	CNFH	86,213	281	156	64.30	0.56	0		
1981	Fall	066025	96	CNFH	47,254	109	75	59.24	0.69	4		
1981	Fall	066026	96	CNFH	42,964	286	240	54.37	0.84	1		
1981	Fall	066027	96	CNFH	41,738	466	208	69.14	0.45	1		
1982	Fall	066036	104	CNFH	44,382	96	33	74.42	0.34	2		
1982	Fall	066037	104	CNFH	43,508	97	18	84.35	0.19	0		
1983	Fall	066042	113	CNFH	50,742	920	447	67.30	0.49	4		
1983	Fall	066043	113	CNFH	49,479	851	457	65.06	0.54	1		
1984	Fall	H50105	83	CNFH	22,558	32	7	82.05	0.22	0		
1985	Fall	H50402	90	CNFH	24,933	334	175	65.62	0.52	0		
1985	Fall	H50403	90	CNFH	28,659	314	205	60.50	0.65	0		
1986	Fall	051839	77	CNFH	51,706	457	105	81.32	0.23	0		
				Total		**4243**	**2126**	**66.62**	**0.50**	**13**	**0**	**0.0%**
1980	Fall	066017	82	RBDD	84,967	393	127	75.58	0.32	8		
1981	Fall	066024	73	Below RBDD	49,003	113	77	59.47	0.68	7		
1981	Fall	066028	73	Below RBDD	44,308	338	250	57.48	0.74	4		
1981	Fall	066029	73	Below RBDD	43,817	391	211	64.95	0.54	0		
1982	Fall	066034	109	Below RBDD	44,498	22	12	64.71	0.55	0		
1982	Fall	066035	109	Below RBDD	45,343	72	12	85.71	0.17	1		
1983	Fall	066040	109	Below RBDD	51,948	1056	286	78.69	0.27	8		
1983	Fall	066041	109	Below RBDD	50,921	1151	328	77.82	0.28	8		
1984	Fall	H50106	98	Below RBDD	23,378	26	4	86.67	0.15	0		
1985	Fall	H50404	106	Below RBDD	26,900	365	149	71.01	0.41	0		
1985	Fall	H50405	106	Below RBDD	27,606	442	202	68.63	0.46	0		
1986	Fall	051840	68	Above RBDD	51,807	358	87	80.45	0.24	2		
				Total		**4727**	**1745**	**73.04**	**0.37**	**38**	**624**	**26.3%**

a- Returns are the number of fish that returned to the hatchery or were recovered from Battle Creek.

Table 10C-4. Stray indices and catch rates for brood years 1987 - 1995 Coleman National Fish Hatchery (CNFH) fall chinook salmon smolts released directly into Battle Creek at the hatchery and at various downstream locations. Since 1992 all fall chinook salmon smolts have been released on-site.

Brood Year	Run	Tag Code	Release Location	Number	Ocean (O)	BC Returns (BC)	Catch Rate (%)	Ratio (BC/O)	Estimated Strays	Stray Index (%)
1987	Fall	051939	CNFH	51,923	394	108	78.49	0.27	0	0.0%
1988	Fall	052037	CNFH	51,074	84	51	62.22	0.61	0	0.0%
1989	Fall	052055	CNFH	51,069	39	15	72.22	0.38	0	0.0%
1990	Fall	0601010113	CNFH	64,337	274	182	60.09	0.66	0	0.0%
1991	Fall	052813	CNFH	49,507	40	34	54.05	0.85	0	0.0%
			Total		831	390	68.08	0.47	0	0.0%
1987	Fall	051940	Below RBDD	48,299	469	115	80.31	0.25		
1988	Fall	052038	Below RBDD	35,905	92	38	70.77	0.41		
1989	Fall	052056	Below RBDD		33	15	68.75	0.45		
1990	Fall	0601010112	Below RBDD		375	223	62.71	0.59		
1991	Fall	052818	Below RBDD		36	41	46.75	1.14		
			Total		1005	432	69.94	0.43	40	8.4%
1987	Fall	051941	Princeton		413	59	87.50	0.14		
1988	Fall	052039	Princeton	47,019	90	36	71.43	0.40		
1989	Fall	052057	Princeton		12	6	66.67	0.50		
1990	Fall	051845/7/8	Princeton	51,201	174	100	63.50	0.57		
1991	Fall	052819	Princeton	51,986	155	52	74.88	0.34		
			Total		844	253	76.94	0.30	143	36.1%
1987	Fall	051942	Benicia	51,371	328	10	97.04	0.03		
1988	Fall	052040	Benicia		198	6	97.03	0.03		
1989	Fall	052058	Benicia		244	20	92.42	0.08		
1990	Fall	0601010104	Benicia	45,038	740	127	85.35	0.17		
1991	Fall	052830	Benicia	50,052	859	111	88.56	0.13		
			Total		2367	274	89.63	0.12	837	75.3%
1992	Fall	0601010803	CNFH	59,697	808	531	60.34	0.66		
1992	Fall	0601010804	CNFH	58,131	1,284	739	63.47	0.58		
1992	Fall	0601010805	CNFH	59,440	1,364	845	61.75	0.62		
1992	Fall	0601141101	CNFH	30,715	586	256	69.60	0.44		
1992	Fall	0601141102	CNFH	28,361	508	258	66.32	0.51		
1993	Fall	053427	CNFH	54,892	140	59	70.35	0.42		
1993	Fall	053428	CNFH	53,430	251	167	60.05	0.67		
1993	Fall	053429	CNFH	62,483	413	207	66.61	0.50		
			Total		5,364	3082	63.62	0.57		
1994	Fall	0601011206	CNFH	52,663	517	343	60.12	0.66		
1994	Fall	0601011207	CNFH	50,036	493	318	60.79	0.65		
1994	Fall	0601011208	CNFH	50,718	345	284	54.85	0.82		
1995	Fall	0601020114	CNFH	295,384	712	496	58.94	0.70		
1995	Fall	0601020115	CNFH	308,443	1,363	1125	54.78	0.83		
1995	Fall	0601020201	CNFH	288,960	1,922	1,975	49.32	1.03		
			Total		5,352	4541	54.10	0.85		

a Returns to Battle Creek include both adults recovered at the hatchery and expanded recoveries for lower Battle Creek returns.

Table 10C-5. Summary table for mean stray indices for releases of fall chinook salmon smolts and fry. Salmon were raised at Coleman National Fish Hatchery, Battle Creek (a tributary to the Sacramento River). Number of groups examined is in parentheses.

Release Location	Stray Index %		
	Brood years 1980 - 1987 fry releases	Brood years 1980 - 1986 smolt releases	Brood years 1987 - 1991 smolt releases
Battle Creek (RM 271.5)	0.0 (4)	0.0 (12)	0.0 (5)
Red Bluff Diversion Dam (RM 243)	47.2 (11)	26.3 (12)	8.4 (5)
Princeton (RM 164)			36.1 (5)
Various Downstream Locations[a]	79.3 (15)		
Benicia (below Delta)			75.3 (5)
Mokolumne River (off river)	89.7 (5)		

a Downstream locations consist of groups of fish released at Courtland, Isleton, and Ryde.

Mean stray indices for brood years 1980 through 1987 fry releases and brood years 1980 through 1986 smolt releases show increased straying for fry, possibly suggesting a greater effect on fry occurring as a result of disruption in the imprinting cycle. Fry releases at the Red Bluff Diversion Dam (RBDD) resulted in a stray index more than double that of smolt releases.

Releases of marked smolts from brood years 1987 to 1991 were part of an evaluation of release sites conducted in cooperation with the California Department of Fish and Game. Analyses of the data demonstrate releasing salmon west of the Delta results in higher ocean contribution rates and likely higher overall survival than releasing salmon upstream. However, the drawback of the survival advantage is that a high percentage of returning fish from downstream release sites stray (stray index = 75.3%). Physical evidence of increased straying associated with the downstream release groups from this study has been collected. Eighteen "strays" from the Benicia release groups were encountered during various field surveys or hatchery operations, two strays from the Princeton release groups were encountered, and no strays were recovered from either the Red Bluff or Battle Creek release groups. However, the majority of strays are not likely to be recovered through existing sampling programs because they end up in various unsampled locations.

Recovery data also suggest that the geographic distribution of straying fish increases with the distance to downstream release sites. Locations of recoveries from Benicia releases include: Clear Creek (n = 1); Feather River (n = 4); American River (n = 8); Mokelumne River (n = 3) Tuolumne River (n = 1); and Merced River (n = 4). The two strays recovered from the Princeton release groups were recovered in Clear Creek, and no strays were recovered/reported from the

Red Bluff Diversion Dam release groups or the on-site Battle Creek release groups. Results of the brood year 1987 - 1991 site of release evaluation are reported in Niemela (1996).

Discussion

General

Our findings of increased straying rates associated with off-site releases are consistent with those of other researchers (see Introduction) including Cramer (1991). Cramer estimated straying rates of Coleman NFH fall chinook salmon juveniles released at Coleman NFH (in Battle Creek) and at various downstream locations. He examined 56 coded-wire tagged (CWT) groups from brood years 1975 through 1984. In his analysis, the 56 CWT groups resulted in 43 records as a number of similar release groups were combined to increase recovery numbers for those groups. He conducted a comprehensive cohort analysis to estimate the number of strays resulting from each of these 43 release groups, and from another subset of these data, generated a mean estimate of stray rates for three release locations (Battle Creek, 9.9%; RBDD 39.3%; and, Knights Landing, 85.6%).

We compared estimates of the stray rates generated by Cramer (1991) with stray indices produced through the methodology we described above. We grouped the records examined by Cramer by release area (Coleman NFH, RBDD, and other downstream sites {Isleton, Ryde, Courtland, Knights Landing, Port Chicago, and Discovery Park}). In doing so, we discounted a few records because Cramer had combined CWT codes of groups released at RBDD with groups released at a downstream site. Two other records also had inconsistencies which warranted their removal from our analysis (PSMFC hatchery recovery or ocean recovery data was substantially different than correct/current information). In all records that remained, recovery data as presented in Cramer (1991) were used (i.e., no corrections made to reflect current PSMFC data), because these data were essential to his cohort analysis.

Results of the analysis support Cramer's previous observations regarding increased stray rates associated with downstream releases (Table 10C-6). In comparing the estimates of straying, the methodology described here generated mean stray indices which were only slightly greater than those reported by Cramer (1991) for RBDD releases, but were less in the case of other downstream releases. This trend can also be seen through examination of the trends in catch rate which increase from on-site releases to those farther downstream (73.9%, 82.4%, and 92.6%; see Table 10C-6). The freshwater site of release, however, is not likely a causal factor in producing an increased ocean catch/harvest rate. Differential harvest rates of this magnitude suggest freshwater recoveries are underestimated, with the underestimation likely being an artifact of increased of straying.

Background Stray Rates

Estimates of stray rates in natural populations have been reported to range from <1% to 25% (Shapovalov and Taft 1954, Quinn et al. 1987, Labelle 1992). While attempts to estimate background straying rates inherent in on-site release groups was not attempted in this analysis, information is available to suggest it is not zero, but is likely no greater than 10% (Cramer 1991, Sholes and Hallock 1979). A quick analysis of late-fall chinook estimates of straying inherent in

Table 10C-6 Comparisons of mean stray rates generated by Cramer (1991) and mean stray indices generated in this analysis for groups of Coleman National Fish Hatchery (CNFH) fall chinook salmon smolts (brood years 1975 - 1984) by release site/area. The numbers of groups in each analysis is shown in parenthesis.

[illegible]	Mean Catch Rate (%)b	Mean Stray Index (%)	Mean Stray Rate (%) (from Cramer 1991)
Battle Creek @ CNFH	73.9	na (5)	9.9 (4)
Red Bluff Diversion Dam	82.4	40.0 (19)	35.4 (11)
Downstream Locationsa	92.6	78.9 (14)	85.6 (4)

a Downstream Locations in the current analysis consist of groups of fish released at Isleton, Ryde, Courtland, Knights Landing, Port Chicago, and Discovery Park. Only fish released at Knights Landing were considered in the analysis conducted by Cramer.

b mean catch rate generated by averaging all catch rates from all groups by release area. Catch rate for each group = (Ocean Recovery/(Ocean Recovery + Hatchery Recovery+Battle Creek Recovery)).

on-site releases was generated here by comparing the number of coded-wire tagged late fall chinook salmon recovered at Coleman NFH (properly homed) and at the Keswick Dam fish trap (strays) between 1993 and 1995 (USFWS 1996b). During those years, approximately 839 Coleman NFH coded-wire tagged late-fall chinook salmon adults were recovered directly at the hatchery, while 32 were collected at the Keswick Dam fish trap in the upper Sacramento River. These recovery values suggest a stray rate of approximately 4%. However, as the Keswick Dam is now the terminus for adult migration in the Sacramento River, we believe that 4% would be reflective of a minimum value, as not all strays would be accounted for at this location. Based on the above analysis of straying of Coleman stocks and other available literature, we conclude that the current levels of estimated straying resulting from on-site release strategies (approximately 10%) is within the background levels inherent with the species.

Genetic Consequences of Straying

For a negative genetic consequence of straying, gene flow must occur into populations genetically dissimilar to the hatchery population. Broodstock sources described in this document reflect the fact that Coleman NFH stocks of fall chinook salmon and late-fall chinook have been largely influenced by existing stocks within Battle Creek and the mainstem Sacramento River. To date, neither allozyme (presentation by David Teel, NMFS, 1999) nor nuclear DNA genetic analyses (Bodega Marine Laboratory, in progress) have documented divergence between Coleman NFH fall and late-fall chinook salmon and their naturally-reproducing counterparts in the Sacramento River. Recent evidence provided by Banks et al. (2000) did, however, suggest hybridization could have occurred during two years of fall chinook spawning, both at Coleman NFH and in the Sacramento River. Data are not, however, indicative of long-term hybridization which would result in a population structure unlike other populations currently described.

For the past fifty years, gene flow has existed between Coleman NFH broodstock and natural populations has existed. Gene flow has resulted from background stray rates, increased straying of off-site releases, and incorporation of natural-origin broodstock at the hatchery. In an analysis of marking studies conducted from 1959 through 1962, Hallock (1977) concluded 58% of the returning adults were recovered at the hatchery, while 42% spawned "naturally." Based on these and other data, Hallock (1977) built life-cycle models and concluded that 6 to 34% of natural spawning populations were composed of hatchery fish, while 25% of broodstock collected for hatchery programs were likely the progeny of natural spawners. Additionally, other sources have reported that 40% (USFWS 1995) to approximately 100% (PSMFC 1998) of the upper mainstem spawning population is composed of hatchery-origin adults. Between 1975 and 1988, Cramer (1991) estimated that hatchery-origin adults comprised 43% (range = 80% in 1982 to 25% in 1988; sd = 18%) of the total number of fall chinook salmon spawning in the mainstem Sacramento.

We believe that additional field studies should be initiated to investigate stray rates of on-site releases. Existing mark rates and tag recovery efforts (carcass surveys) are not adequate to recover sufficient coded-wire tagged fish at rates expected through previous research. For example, in 1996, only 11 of the 7,535 fall chinook salmon carcasses recovered on the mainstem carcass survey were marked. Expanding these 11 for an estimated basin-wide marking rate of 2% to 5% would expand that number to 220 or 550. This results in an estimate of hatchery proportion in the 1996 natural spawning population at 3-7%. Almost identical results were generated in 1997. This percent composition of hatchery fish in the upper Sacramento River is substantially less than other figures presented, or assumptions made in regard to expected or suspected straying rates.

Straying of Late-fall Chinook Salmon Delta Releases

Several experimental releases of late-fall chinook juveniles from Coleman NFH have occurred in the Delta during recent years to conduct a variety of research projects. Adults returning from these release groups have in increased tendency to stray. Late-fall strays have been encountered in the American River. It is unlikely that any late-fall strays would be used in hatchery operations in the American River because of their late timing of return and spawning. An adipose fin-clip also differentiates Coleman NFH late-fall chinook from hatchery fall chinook in the American River (no marked adults are used in spawning operations at the American River Hatchery; Alan Baracco, CDFG, personal communication). However, successful natural spawning within the American River (and elsewhere) may occur. Prior to releasing late-fall chinook salmon in the Delta, the Service requires the agencies or organizations proposing research to obtain approval from the appropriate regulatory agencies (e.g., NMFS, CDFG). To justify the risks posed by increased rates of straying that result from off-site releases, it is necessary to balance the benefits to be achieved through accomplishing goals of each research project.

Conclusions

It is the goal of the Service's Coleman NFH to keep stray rates at minimum levels. The results of the analysis presented here were similar to results presented by Cramer (1991), Sholes and

Hallock (1979)[1], and others. Actions which promote straying of hatchery fish (e.g., downstream releases) should continue to be avoided unless justified through research needs, as with the current Delta releases of late-fall chinook salmon smolts. The Service believes that the current release practices for fall and late-fall chinook salmon (with the exception of Delta releases mentioned previously) reduce straying to background rates associated with adaptive traits common to all populations of chinook salmon. Further, we conclude that, since all stocks propagated at Coleman and Livingston Stone NFH's are contained within the ESU's of the natural stocks, genetic impacts from natural (i.e., background) stray rates are minimal.

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[1] In comparing on-site hatchery releases and releases of yearling fall chinook salmon from the Feather River National Fish Hatchery, Sholes and Hallock (1979) reportedly found a 10% stray rate for fish released on site compared to a 70% stray rate for releases made near Sacramento.

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Appendix 10D. Estimated Timing and Number of Juvenile Salmonids Outmigrating from Battle Creek

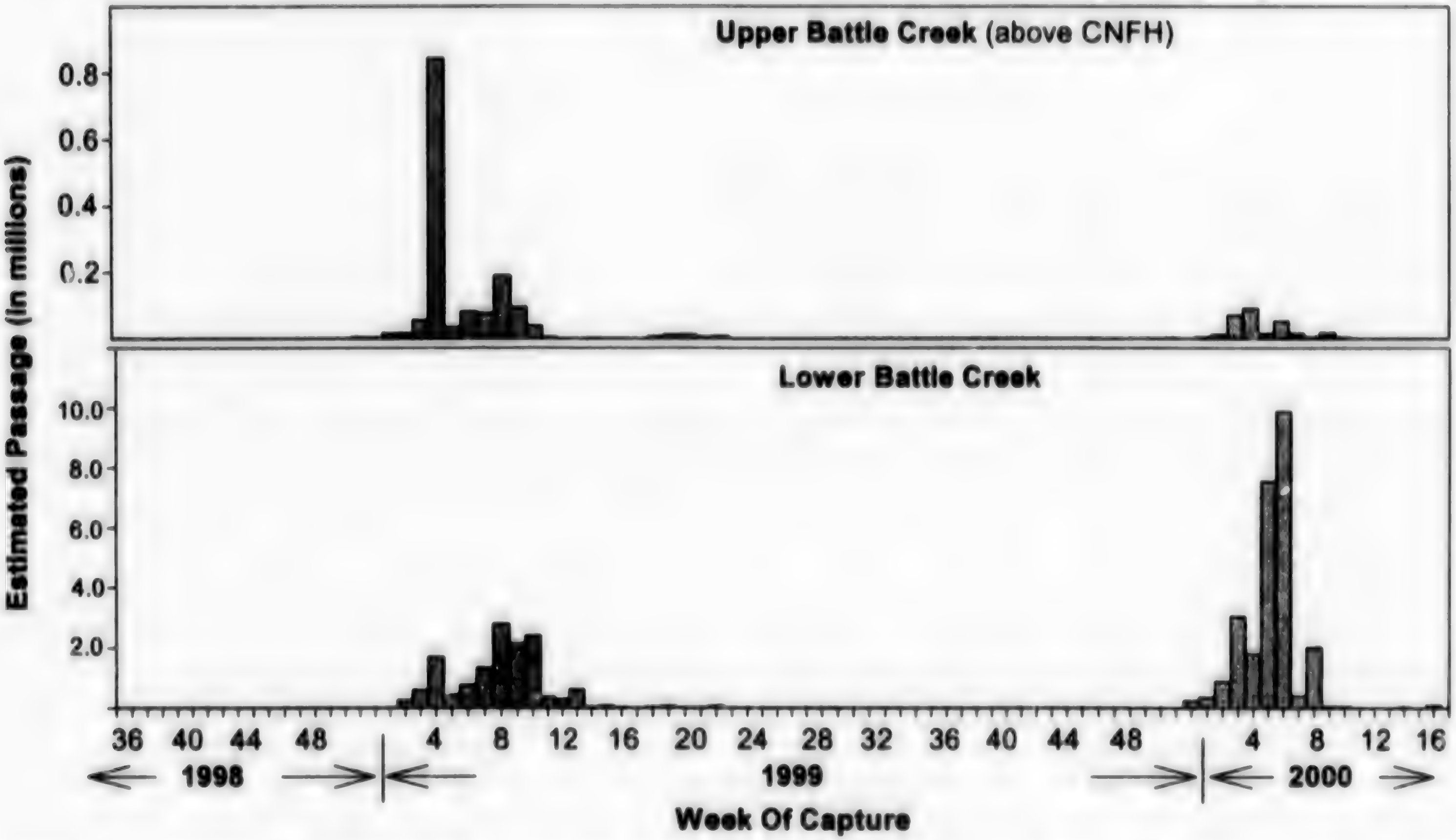

Figure 10D-1. Weekly passage estimates of juvenile fall chinook salmon in Battle Creek, California from rotary screw trap data (USFWS, Red Bluff FWO, unpublished data). Run determination is based on size-class criteria (Shiela Greene, CDFG). The upper Battle Creek trap (creek mile {CM} 5.9) is located just upstream and the lower trap (CM 2.8) is located approximately 3 miles downstream of Coleman National Fish Hatchery. Estimates were generated using multiple mark/recapture trials. Week 1 was defined as the first week of 1999 (e.g., contains January 1). Weeks prior to week 1 were numbered consecutively in descending order beginning with 52; weeks after week 1 were numbered in ascending order.

450

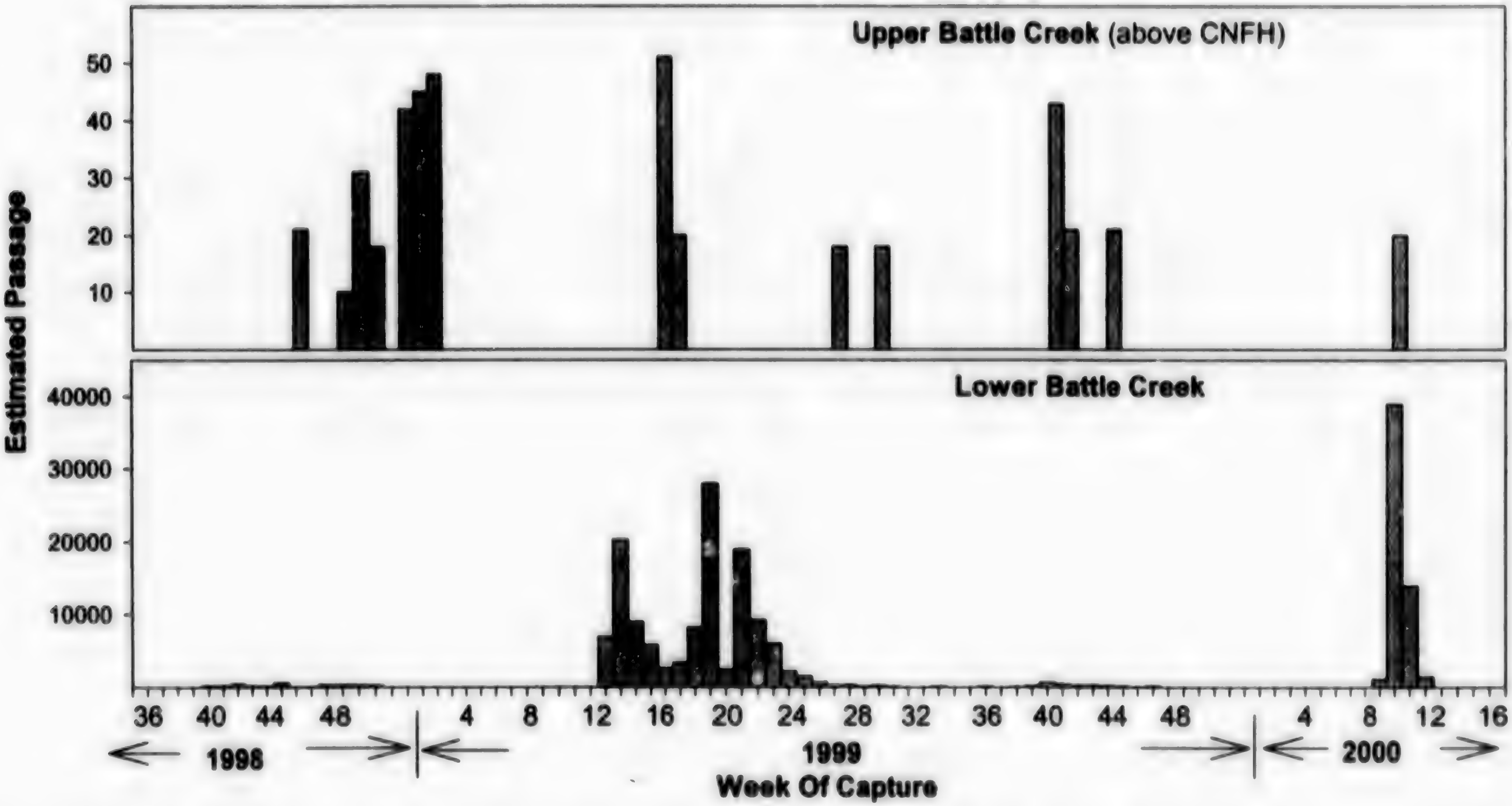

Figure 10D-2. Weekly passage estimates of juvenile late-fall chinook salmon in Battle Creek, California from rotary screw trap data (USFWS, Red Bluff FWO, unpublished data). Run determination is based on size-class criteria (Shiela Greene, CDFG). The upper Battle Creek trap (creek mile {CM} 5.9) is located just upstream and the lower trap (CM 2.8) is located approximately 3 miles downstream of Coleman National Fish Hatchery. Estimates were generated using multiple mark/recapture trials. Week 1 was defined as the first week of 1999 (e.g., contains January 1). Weeks prior to week 1 were numbered consecutively in descending order beginning with 52; weeks after week 1 were numbered in ascending order.

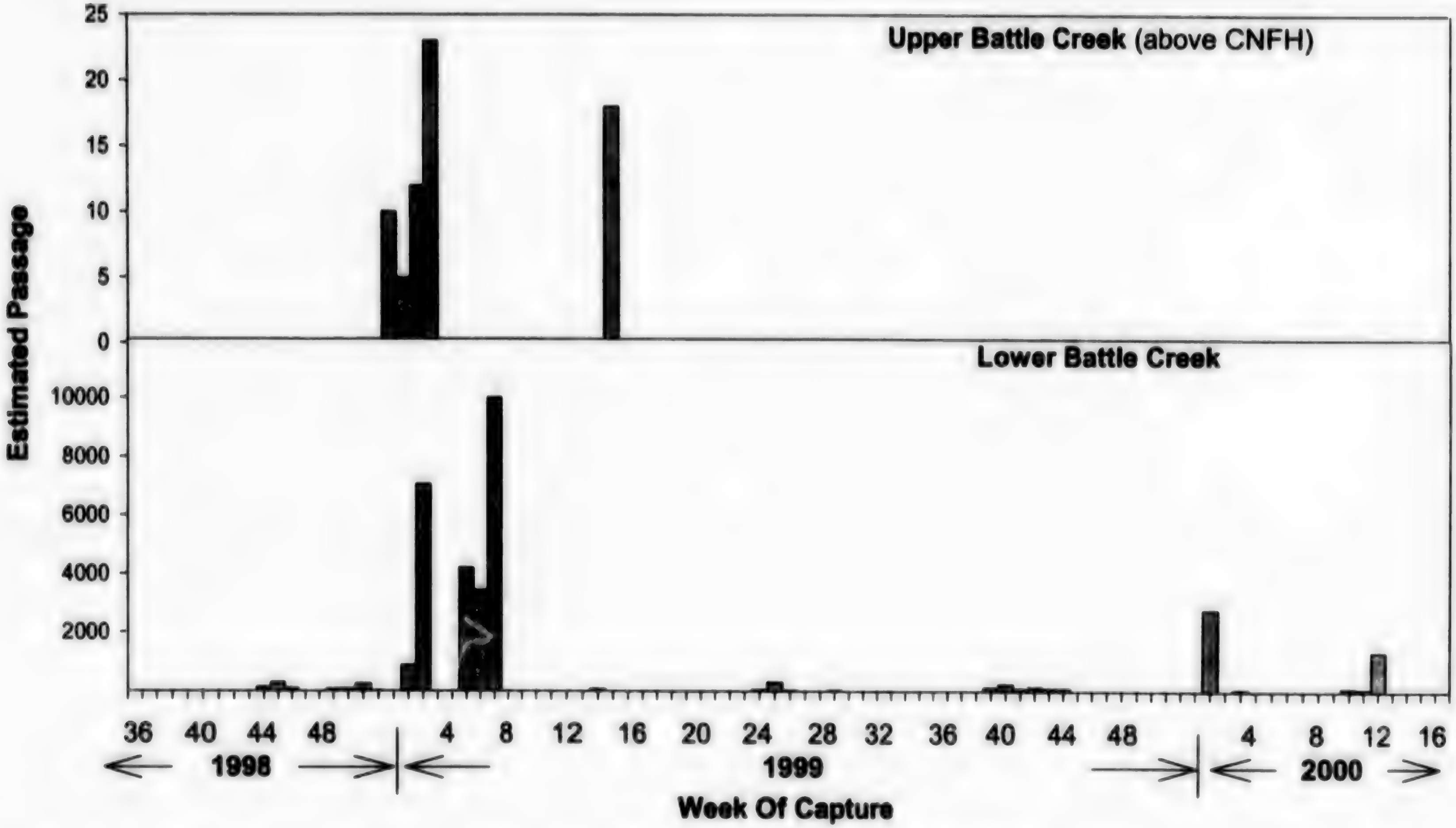

Figure 10D-3. Weekly passage estimates of juvenile winter chinook salmon in Battle Creek, California from rotary screw trap data (USFWS, Red Bluff FWO, unpublished data). Run determination is based on size-class criteria (Shiela Greene, CDFG). The upper Battle Creek trap (creek mile {CM} 5.9) is located just upstream and the lower trap (CM 2.8) is located approximately 3 miles downstream of Coleman National Fish Hatchery. Estimates were generated using multiple mark/recapture trials. Week 1 was defined as the first week of 1999 (e.g., contains January 1). Weeks prior to week 1 were numbered consecutively in descending order beginning with 52; weeks after week 1 were numbered in ascending order.

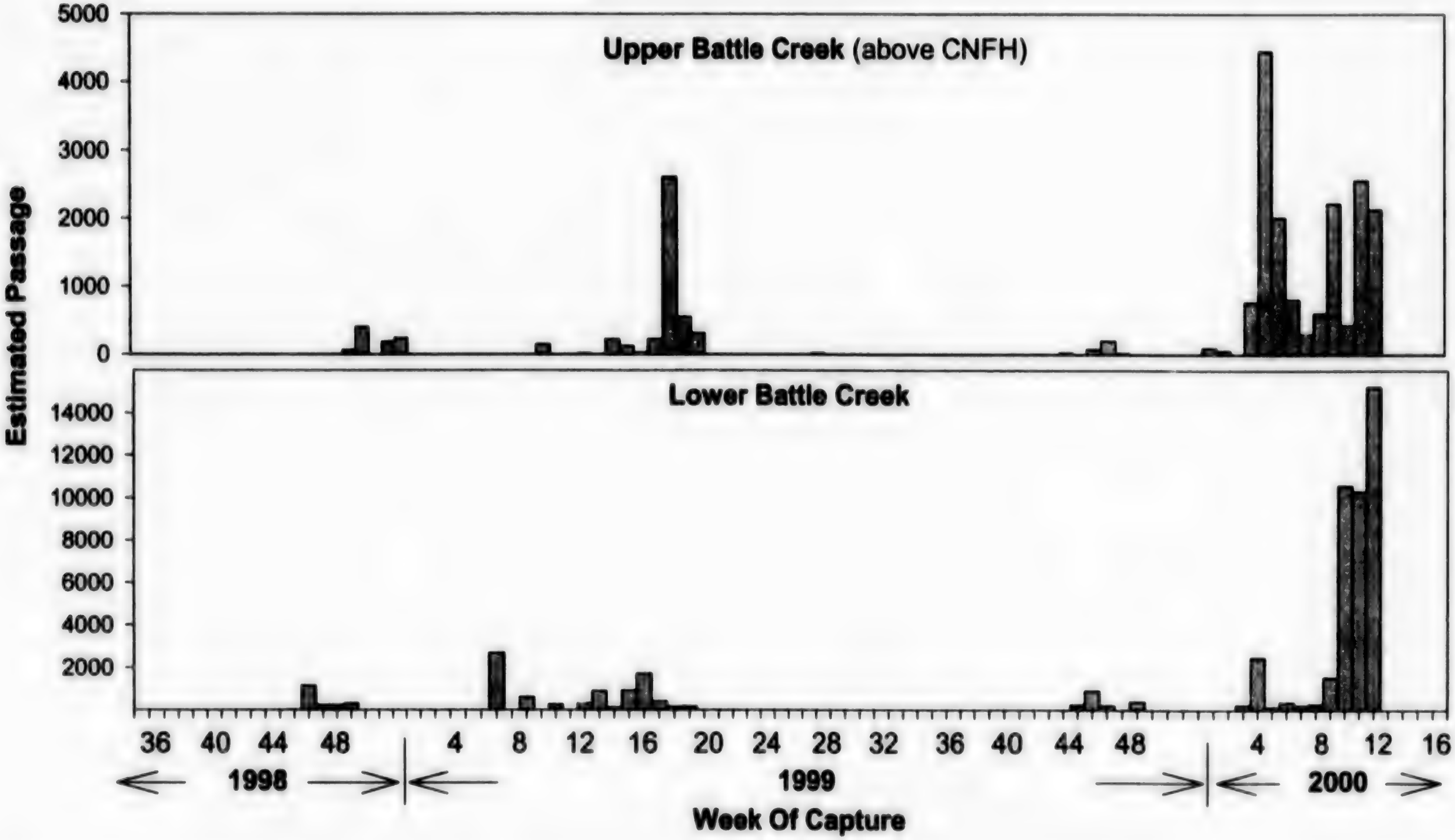

Figure 10D-4. Weekly passage estimates of juvenile spring chinook salmon in Battle Creek, California from rotary screw trap data (USFWS, Red Bluff FWO, unpublished data). Run determination is based on size-class criteria (Shiela Greene, CDFG). The upper Battle Creek trap (creek mile {CM} 5.9) is located just upstream and the lower trap (CM 2.8) is located approximately 3 miles downstream of Coleman National Fish Hatchery. Estimates were generated using multiple mark/recapture trials. Week 1 was defined as the first week of 1999 (e.g., contains January 1). Weeks prior to week 1 were numbered consecutively in descending order beginning with 52; weeks after week 1 were numbered in ascending order.

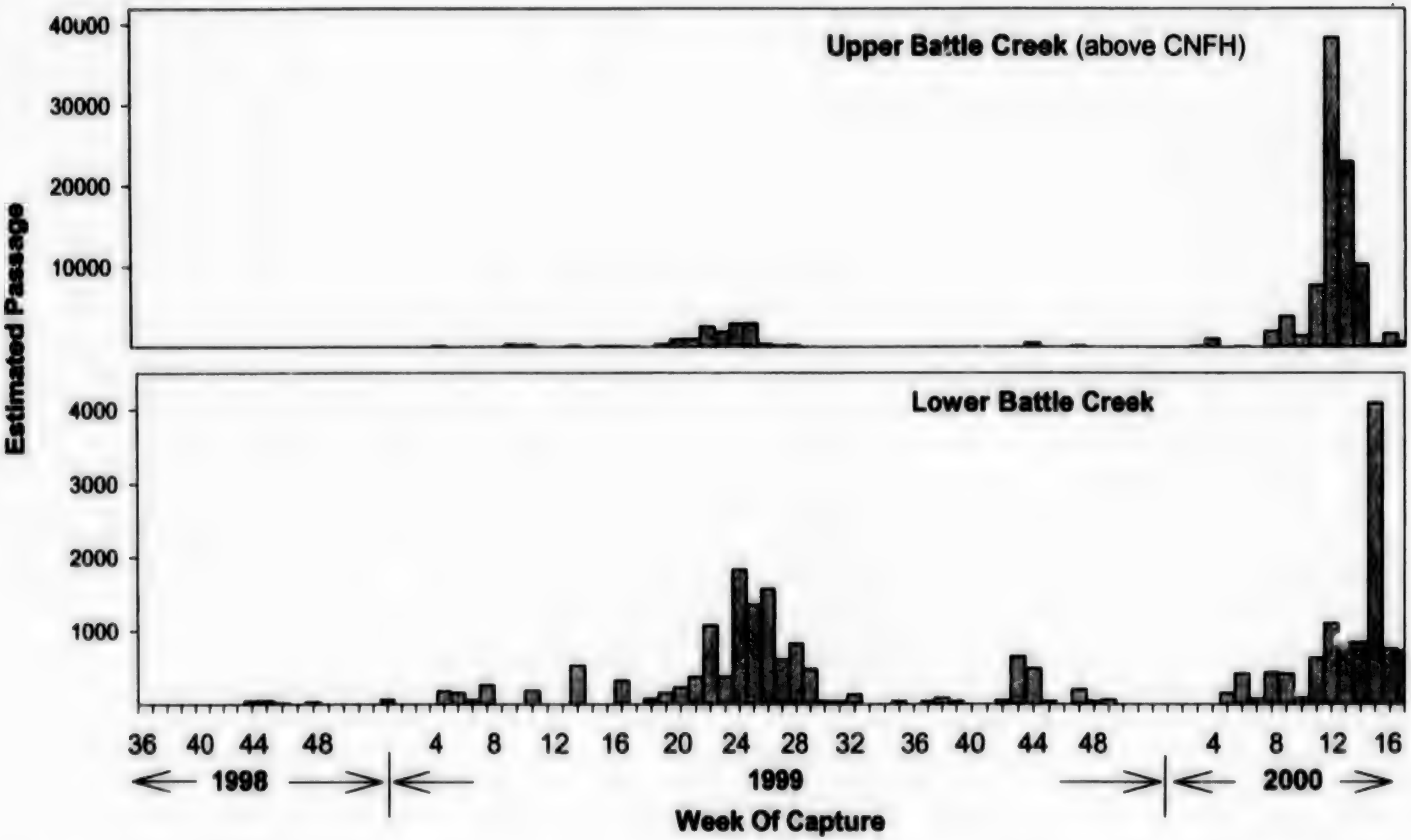

Figure 10D-5. Weekly passage estimates of juvenile *Oncorhynchus mykiss* in Battle Creek, California from rotary screw trap data (USFWS, Red Bluff FWO, unpublished data). The upper Battle Creek trap (creek mile {CM} 5.9) is located just upstream and the lower trap (CM 2.8) is located approximately 3 miles downstream of Coleman National Fish Hatchery. Estimates were generated using multiple mark/recapture trials. Week 1 was defined as the first week of 1999 (e.g., contains January 1). Weeks prior to week 1 were numbered consecutively in descending order beginning with 52; weeks after week 1 were numbered in ascending order.

13 3 Attachments

Attachment 1 1	Letter to Mr Mike Aceituno (National Marine Fisheries Service) and Mr Bary Stacey (California Department of Fish and Game)documenting future operation of the fish ladder in the Coleman barrier weir

United States Department of the Interior

FISH AND WILDLIFE SERVICE
NORTHERN CENTRAL VALLEY FISH AND WILDLIFE OFFICE
10950 Tyler Road
Red Bluff, CA 96080

12 June 2000

Mr Mike Aceituno
National Marine Fisheries Service
Sacramento Field Office Supervisor
650 Capital Mall Blvd Suite 6070
Sacramento California 95814-4706

Mr Gary Stacey
California Department of Fish and Game
Fisheries Program Manager
NCNCR - Region 1
601 Locust Street
Redding California 96001

Dear Mr Aceituno and Mr Stacey

This letter serves to document decisions made at a meeting on June 5 2000 regarding the operation of the U S Fish and Wildlife Service s (Service) Coleman National Fish Hatchery (NFH) barrier weir Meeting attendees included Dan Free (NMFS) Michael Lacy (CDFG) Harry Rectenwald (CDFG) Scott Hamelberg (USFWS) and Mike Keeler (USFWS) The group agreed to delay the closure of the barrier weir s upstream fish ladder until 1 September 2000 This action, consistent with efforts to afford additional passage opportunity for spring chinook salmon represents an increased passage period of two months over last years operation

The proposal to delay the closure of the upstream fish ladder was forwarded by the Service s Northern Central Valley Fish and Wildlife Office (NCVFWO) and the Coleman NFH In regard to hatchery operations the purpose of the barrier weir is to congregate broodstock for production programs at Coleman NFH As congregation of fall chinook salmon broodstock below the barrier weir is not considered necessary prior to 1 September the upstream ladder could remain open until this time Previous situations warranting upstream fish ladder closure dates prior to1 September (i e disease concerns and spring chinook salmon segregation) have been/will be largely remedied through the construction of the ozone generation facility at Coleman NFH and flow and passage improvements in other areas of the watershed associated with Battle Creek restoration

Video monitoring of passage through 1 September will be conducted by NCVFWO In the event large numbers of adipose fin clipped adults (i e hatchery origin fall chinook salmon) are determined to be ascending the ladder, an effort to trap and remove adipose fin clipped individuals may be initiated or perhaps, the upstream ladder may be closed at an earlier date to prevent their passage The decision to initiate a trapping effort or close the upstream ladder will be made at a later date Any in season decisions to modify operations from the current agreement (i e provide for and video monitor fish passage through the Coleman NFH barrier weir s upstream fish ladder until 1 September 2000) will be made by representatives of the trustee agencies (NMFS CDFG USFWS) and will be based on summarized (weekly) passage data including totals of marked and unmarked fish. All in season passage data will be generated and distributed by NCVFWO

Please feel free to contact myself or Kevin Niemela at (530) 527 3043 if you have any questions regarding these decisions/agreements

Sincerely

James G Smith
Project Leader

cc
Harry Rectenwald, CDFG Redding
Larry Week CDFG Sacramento
Michael Lacy CDFG Sacramento
Dan Free NMFS Sacramento
Mike Keeler USFWS, Anderson
Mary Ellen Mueller USFWS Sacramento
Scott Foott, USFWS Anderson
Scott Hamelberg USFWS Red Bluff

Attachment 3 1 Interagency Agreement between U S Fish and Wildlife Service and U S Bureau of Reclamation concerning the funding and operation of the Coleman National Fish Hatchery Anderson California

JUN 3 0 1993

O RED BLUFF, CA

INTERAGENCY AGREEMENT

between

U S FISH AND WILDLIFE SERVICE

and

U S BUREAU OF RECLAMATION

concerning

the funding and operation of the

COLEMAN NATIONAL FISH HATCHERY
Anderson, California

a feature of the
CENTRAL VALLEY PROJECT

March 19 1993

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COPY FOR YOUR INFORMATION

U S DEPARTMENT OF THE INTERIOR
INTERAGENCY AGREEMENT
BETWEEN
BUREAU OF RECLAMATION
AND
FISH AND WILDLIFE SERVICE
CONCERNING
COLEMAN NATIONAL FISH HATCHERY
A MITIGATION FEATURE OF THE
CENTRAL VALLEY PROJECT

This Interagency Agreement (Agreement) is made and entered into between the Bureau of Reclamation hereinafter Reclamation and the Fish and Wildlife Service hereinafter the Service to establish general principles and describe the responsibilities of both agencies concerning the custody responsibility and the funding for Coleman National Fish Hatchery (Hatchery)

This Agreement is made under the authority of the Fish and Wildlife Coordination Act as amended (16 U S C 661 et seq) and Federal Reclamation law consisting of the Reclamation Act of 1902 (32 Stat 388) and acts amendatory thereof and supplementary thereto including but not limited to section 2 of the Act of August 26 1937 (50 Stat 844) as amended and supplemented the Act of August 4 1939 (53 Stat 1187) as amended and supplemented Title II of the Act of October 12 1982 (96 Stat 1263) as amended and Title XXXIV of the Act of October 30 1992 (Public Law No 102 575)

WHEREAS the Hatchery was constructed by Reclamation in 1943 as a part of the Central Valley Project (Project) facilities for the salvage protection and preservation of the fish which spawned in the upper Sacramento River Basin prior to construction of Shasta and Keswick Dams and

WHEREAS the Service and Reclamation entered into a Memorandum of Agreement approved September 21 1948 whereby Reclamation transferred to and the Service accepted the full custody and responsibility for the Hatchery and thereafter sought and received directly appropriated funds for this purpose and

WHEREAS the parties further entered into a supplementary Memorandum of Agreement approved on December 5 1951 which states in part that the operation of the Hatchery is a continuing responsibility of both parties and any special problems arising but not provided for in the 1948 Agreement as amended shall be the subject of further agreement and

WHEREAS there is a need for the Hatchery to be operated as a mitigation facility of the Project to partially offset associated anadromous fish losses and that the future costs associated with its operation maintenance and evaluation should be properly allocated among Project beneficiaries and recovered in accordance with Federal Reclamation law and

WHEREAS the Service desires to continue its operation maintenance and evaluation of the Hatchery program and

WHEREAS Reclamation has the authority and is willing to continue to provide Project power and energy needed to operate Hatchery mitigation facilities

NOW THEREFORE RECLAMATION AND THE SERVICE AGREE AS FOLLOWS:

1 This Agreement supersedes the agreements approved on July 11 1947 September 21 1948 December 5 1951 April 27 1953 and September 9 1987 between Reclamation and the Service specific to the Hatchery by consolidating applicable and pertinent elements of said agreements It further describes future funding custody and responsibilities of each agency

2 The Hatchery shall be managed operated evaluated and maintained in accordance with a mutually agreed upon hatchery management plan prepared by the Service

3 Meet not less than annually to coordinate and review the ongoing operation of the Hatchery to ensure appropriate mitigation objectives as identified in a mutually agreed upon hatchery management plan are being met and to identify and plan for future activities including funding needs

RECLAMATION RESPONSIBILITIES:

1 Commencing October 1 1993 Reclamation shall

(a) Pay all applicable Hatchery costs including the costs of appropriate rehabilitation of existing Hatchery facilities and equipment and the costs of any appropriate additional mitigation facilities and

(b) Arrange for the recovery of such costs from Project beneficiaries in accordance with Federal Reclamation law

2 Establish an annual transfer fund contract with the Service for implementing provisions in 1(a) above utilizing the On line Payment and Collection (OPAC) system for invoicing and payment

3 As the action agency responsible for mitigation actions required to offset fishery resource losses associated with the Project Reclamation shall provide necessary oversight and review to ensure that the Hatchery meets objectives of the hatchery management plan

4 Reclamation shall retain administrative responsibility for and shall operate and maintain the Keswick Dam Fish Trap and the present fish collecting devices

5 In its operation of the Project Reclamation shall make every effort to maintain flows and temperatures in the Sacramento River which are necessary

for fishery maintenance and shall consult with the Service when critical fishery conditions are anticipated

6 Reclamation shall provide Project power and energy to the Hatchery at no cost to the Service as required by mutual agreement for mitigation purposes up to a maximum of 2200 kilowatts

IT IS THE RESPONSIBILITY OF THE SERVICE TO:

1 Prepare and submit to Reclamation a hatchery management plan for mitigating fishery resources impacted by the Project

2 Have full operational custody and program responsibility for the Hatchery related facilities and appurtenances and to manage operate evaluate and maintain the Hatchery in accordance with the current hatchery management plan

3 Operate the Hatchery as a unit of the Service s Fishery Resources Program activity and National Fish Hatchery System

4 Provide an annual report to Reclamation on Hatchery activities and expenditures associated with the operation maintenance and evaluation of the Hatchery including estimates for future funding needs in implementing the hatchery management plan

5 Perform biological studies and investigations as may be needed pursuant to Fish and Wildlife Coordination Act requirements

6 Collect adult fish at the Keswick Dam Fish Trap and transfer them to the Hatchery for spawning and release of the progeny into the Sacramento River system or such other locations as may be agreed

7 Provide Reclamation on a quarterly basis the 5 year power and energy use projections for the Hatchery to facilitate Project power and energy planning

8 Provide Reclamation with at least an eight month advance notice of any proposed changes in the voltage of the transmission lines to the Hatchery to facilitate electrical metering changes

9 Maintain at least a 95 percent overall electrical power factor for the Hatchery load served by Project power and energy

GENERAL

1 Amendments hereto may be proposed by either Reclamation or the Service and shall become effective through a written agreement between the parties

2 No member of or delegate to Congress or resident commissioner shall be admitted to any share or part of this agreement or to any benefit that may arise from it

3 This agreement shall become effective upon the latest date written or printed below It shall be reviewed by both parties no later than July 1 1995 and every 5 years thereafter for adequacy compliance necessary or desired changes and/or termination

4 This agreement shall remain in force and effect unless terminated by either party upon 1 year s written notice

Marvin L Plenert
Regional Director
Western Region
U S Fish and Wildlife Service

Date March 15, 1993

Regional Director
Mid Pacific Region
U S Bureau of Reclamation

Date 3/19/93

XA F

United States Department of the Interior

TAKE PRIDE IN AMERICA

BUREAU OF RECLAMATION
Mid-Pacific Regional Office
2800 Cottage Way
Sacramento California 95825-1898

IN REPLY REFER TO
MP 401
ENV 4 00

MAR [illegible]

Memorandum

To Regional Director U S Fish and Wildlife Service Portland OR

From Regional Director Sacramento CA

Subject Interagency Agreement Concerning Coleman National Fish Hatchery Central Valley Project (Fish Hatchery)

Enclosed for your files is an executed copy of the subject agreement describing the responsibilities of both agencies concerning the custody responsibility and the funding for the Coleman National Fish Hatchery (CNFH) Per this agreement the hatchery will once again become a mitigation feature of the Central Valley Project (CVP) while continuing to be operated by the U S Fish and Wildlife Service (Service) as a unit of the National Fish Hatchery System

Execution of this agreement on behalf of Reclamation represents a significant step towards assisting Reclamation in offsetting fishery impacts associated with the construction and operation of the CVP and is consistent with the intent and direction of Public Law 102 575 the Central Valley Project Improvement Act

Per the agreement Reclamation will become fully responsible for funding all mitigation costs including rehabilitation costs associated with the hatchery beginning in fiscal year 1994 We will be working with your staff soon on the preparation of specific agreements that will enable the transfer of funds to the Service for your mitigation activities at the hatchery

The development of this agreement was the result of important negotiations our staffs held over the last several years We appreciate the efforts and dedication of Mr Jerry Grover who contributed significantly to this agreement

We look forward to your continued operation of CNFH and to the preparation of the mutually agreed upon hatchery management plan that will provide the overall direction for the management operation and evaluation of the hatchery as a integral mitigation feature of the CVP

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Should you have any further questions concerning this agreement please contact Mr Gary Sackett at (916) 978 4933

Enclosure

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Updated February 1 1992

CENTRAL VALLEY PROJECT FISHERY MITIGATION COST
SHASTA/KESWICK DAM

Coleman NFH CVP Costs	Funding Estimates 1991	1992	1993	1994	1995
Personnel Salaries	$523 400	$557 900	$592 700	$629 700	$669 000
Personnel Benefits	143 600	150 300	172 600	183 400	194 800
Other Personnel Costs	10,800	10,800	15,200	16,100	17,200
Sub total Personnel Costs	$677 800	$719 000	$780 500	$829 200	$881 000
Transportation	$ 13 000	$ 13 500	$ 14 300	$ 15 100	$ 16 000
Utilities 1/	4 300	4 400	4 500	4 600	4 700
Contractual Services	32 400	37 800	40 000	42 300	44 800
Fish Feed and Supplies	287,200	343,100	365,400	389,200	414,500
Sub total Services and Supplies	$336 900	$398 800	$424 200	$451 200	$480 000
Equipment	$ 59 400	$ 91 800	$ 73 600	$ 51 800	$ 93 700
Maintenance 2/	103,600	110,000	140,000	242,000	178,200
Sub total Maintenance	$163 000	$201 800	$213 600	$293 800	$271 900
Fish Health 3/	$ 47 100	$ 50 000	$ 70 000	$ 74 600	$ 79 400
Hatchery Evaluation	150,700	159,900	170,300	181,400	193,200
Sub total Technical Support	$197 800	$209 900	$240 300	$256 000	$269 600
Grand Totals	$1 375 500	$1 529 500	$1 658 600	$1 830 200	$1 902 500

1/ Does not include project power costs

2/ Excludes major rehabilitation and construction

3/ In 1993 includes additional costs associated with monitoring the threatened winter run chinook salmon

Attachment 3 2 **Revised Position Paper on the Battle Creek Watershed Shasta and Tehama Counties California**

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO

Sacramento Fish and Wildlife Office
3310 El Camino Avenue Suite 130
Sacramento California 95821 6340

April 3 1998

To Battle Creek Restoration Interested Parties

Subject Revised Position Paper on the Battle Creek Watershed Shasta and Tehama Counties California

The enclosed revised Position Statement was developed to clarify the Fish and Wildlife Service s (Service) activities in restoring Battle Creek for anadromous fish It incorporates comments received at the March 4 1998 Battle Creek Working Group Meeting The position statement indicates how the Service will fulfill its mission and work with all stakeholders in restoration of anadromous fish to the watershed and maintain the Coleman National Fish Hatchery operations

If you have any questions about this matter please contact Patricia Parker at (530) 527 3043 or Steve Hirsch at (916) 979 2129

Sincerely

Wayne S White
Geographic Assistant Regional Director
Central Valley/San Francisco Bay Ecoregion

Enclosure

April 3 1998

USFWS POSITION PAPER
BATTLE CREEK WATERSHED

The mission of the USFWS is:

To conserve, protect and enhance the Nation s fish and wildlife and their habitats for the continuing benefit of people.

Purpose: This document describes how the USFWS will fulfill its mission in the Battle Creek watershed through implementation of the Anadromous Fish Restoration Program The USFWS through its stewardship responsibilities and its role as operator of the Coleman National Fish Hatchery (CNFH) will continue to play a leadership role in Battle Creek watershed activities to ensure that both Battle Creek and CNFH improvements occur in a timely manner

USFWS Goal: Restore the Battle Creek watershed for naturally produced anadromous salmonids while integrating CNFH operations

USFWS Objectives:

Maximize habitat potential
Conduct monitoring & assessment of natural and hatchery fish populations
Maximize CNFH operational flexibility
Ensure stakeholder involvement
Negotiate a long term operations agreement

Habitat objective: Maximize habitat to benefit naturally produced anadromous salmonid populations.

The USFWS fully supports the February 27 1998 version of the Time for Action proposal or its biological equivalent The current proposal s habitat improvement measures will provide a high degree of certainty to benefit anadromous fish populations All of these habitat restoration measures will assist population recovery efforts for steelhead winter and spring chinook These measures should also benefit fall and late fall chinook once populations of the more sensitive species are protected In the future all reaches of the creek below the natural barrier falls should be made available for anadromous fish production

Fish assessment objective: Conduct monitoring & assessment of natural and hatchery fish populations

The USFWS believes an essential component of the Battle Creek fishery restoration effort is to monitor and assess fish populations before during and after restoration actions (e g redd carcass and outmigrant studies) The USFWS supports attaining long term funding for these efforts

Hatchery production objective: Maintain and enhance CNFH s operational flexibility with a view towards future hatchery production obligations and responsibilities.

The USFWS s CNFH plays an important role in mitigating the Central Valley Project impacts to anadromous fish CNFH s operations need to be integrated with natural production in Battle Creek in a timely manner Completion of the ozone water treatment system alleviates disease concerns associated with upstream passage of anadromous salmonids To further facilitate restoration, USFWS is also actively pursuing 1) modifications to the intake structures to ensure adequate water supply (quality and quantity) and 2) installation of state of the art fish screens to exclude naturally produced fish from the hatchery s water intake

The CNFH barrier weir has long been operated to provide broodstock to the hatchery USFWS is exploring improvements to the weir that will better allow the weir to be operated in a manner that complements and even enhances the restoration of natural spawning populations

Stakeholder objective: Ensure stakeholder involvement.

USFWS supports engaging all stakeholders in the Battle Creek restoration effort and believes that the Battle Creek Working Group and Battle Creek Watershed Conservancy meetings are successfully serving this purpose USFWS believes that a pro active outreach program including frequent updates on the restoration effort and accompanying the NEPA/CEQA/ESA processes is a key factor for continued successful restoration efforts

Long term operations objective: Negotiate a long term operations package.

USFWS appreciates the constructive participation of Pacific Gas & Electric Company (PG&E) staff in ongoing discussions to identify fish friendly improvements to PG&E s facilities that would facilitate the restoration effort USFWS recognizes that restoration planning has been ongoing for some time and is anxious to continue discussions with PG&E California Department of Fish & Game (CDFG) U S Bureau of Reclamation (USBR) and National Marine Fisheries Service (NMFS) to develop a long term operations package that could accompany the restoration effort This package would reduce conflicts between listed species and PG&E s hydropower operations In the near future USFWS will convene a meeting with CDFG USBR and NMFS to outline the respective resource agency s roles responsibilities timelines and parameters that will be included in this package This package could form the basis of a comprehensive plan that the resource agencies and PG&E could submit to the Federal Energy Regulatory Commission (FERC) to support PG&E s license modifications

Attachment 3 3 A final statement of work for the Analysis of Hatchery Management Alternatives generated during the Coleman National Fish hatchery Re evaluation Process

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Northern Central Valley Fish and Wildlife Office
10950 Tyler Road
Red Bluff California 96080

July 21 2000

Memorandum

TO Vickie Ruggles Contracting and General Services

FROM FOR James G Smith Project Leader NCVFWO Patricia L Parker

SUBJECT A final statement of work for the Analysis of Hatchery Management Alternatives generated during the Coleman National Fish Hatchery Re-evaluation Process [AFRP Project 00 E-1]

Enclosed is the final statement of work for the above referenced project This document follows the draft statement of work (and signed acquisition request) that we sent you on July 7 2000 We have considered and incorporated review comments provided by Scott Foott (CA/NV FHC) and Scott Hamelberg (CNFH) Additional comments were also provided by Kevin Niemela (NCVFWO Hatchery Evaluation) and Tricia Parker (AFRP Habitat Restoration Coordinator)

We understand that you have posted a notice in the Commerce Business Daily (July 5 2000) announcing that bid packages for this project will soon be released We also understand that you will soon be posting this project on the National Business Center web site and sending electronic/hard copy bid packages to the 23 contractors that we have identified as potentially being interested in bidding on this work proposals will be due to you approximately 30 days after the Issue Date

Thank you for your assistance on this project If you have any questions please contact Tricia Parker of my staff

cc Dot Baker (without attachments)

July 21 2000

Statement of Work

Title. Analysis of Management Alternatives generated during the Coleman National Fish Hatchery Re evaluation Process [00 E 1]

Purpose. Integrate Coleman National Fish Hatchery with restoration of natural populations of salmon and steelhead in Battle Creek and/or minimize impacts of hatchery operations on anadromous salmonids Sacramento River basinwide

Background

Battle Creek is recognized as unique among streams in the Sacramento River basin in that it harbors all four runs of chinook salmon and steelhead trout The spring fed nature of Battle Creek ensures an abundant year round supply of cold stream flows suitable for natural production Early in the 20th century the abundant water supply and steep stream gradient also made Battle Creek appealing for hydro power development Forty years later the federal government recognized that Battle Creek also provides a prime site for the federal fishery facility needed to mitigate for the spawning habitat blocked by Shasta Dam Major efforts are now underway to restore passage for anadromous salmonids whose access into upper Battle Creek has been impeded due to hydro power and hatchery operations

The U S Fish and Wildlife Service (Service) has been a leader in all aspects of negotiations and activities to restore Battle Creek Restoration and monitoring activities currently underway or planned for Battle Creek are guided by the goals objectives and strategies developed in the Anadromous Fish Restoration Program (AFRP) Plan (USFWS 1997 or see <http //www delta dfg ca gov/afrp>) The Battle Creek watershed in the upper Sacramento River is recognized as critically important to achieving AFRP goals because it is considered to be one of few remaining tributaries with a high potential for restoring self sustaining populations of winter and spring chinook salmon and steelhead trout all protected under the provisions of the federal Endangered Species Act (ESA) The AFRP guided approach in the Battle Creek restoration effort relies heavily on local involvement and partnerships with landowners watershed workgroups public organizations county and local governments and state and federal agencies Additionally the AFRP uses the authority and resources provided by the Central Valley Project Improvement Act (CVPIA) to restore anadromous fish and their habitats

Coleman National Fish Hatchery (NFH) has been operated by the Service on Battle Creek since 1942 Coleman NFH plays a critical role as the principle remaining feature of the original Shasta Salvage Plan to mitigate for negative effects on Central Valley salmon populations caused by the construction of Shasta Dam Because of its location on Battle Creek facility operations and management at the Coleman NFH are intimately linked to the Battle Creek restoration process in three primary areas 1) Battle Creek serves as the hatchery s sole source of water 2) the hatchery operates a barrier weir and fish ladder in Battle Creek to facilitate seasonal congregation and collection of broodstock and, 3) a substantial portion of the juvenile fish produced at the hatchery are liberated directly into Battle Creek To facilitate restoration of natural salmonid populations in Battle Creek, Coleman NFH s operations need to be fully integrated with the AFRP guided recovery process The intent to restore the Battle Creek watershed for naturally produced anadromous salmonids while integrating hatchery operations was formally advanced in a Service position paper (Wayne S White Geographic Assistant Regional Director USFWS April 3 1998) The position paper describes how the Service will fulfill its mission in the Battle Creek watershed through implementation of the AFRP

Major changes are already underway to integrate the Coleman NFH with Battle Creek restoration Work in progress includes modifications to the hatchery s barrier weir and upstream ladder improvements/screening of the water intakes and construction of an ozone treatment plant These three activities in conjunction with reallocation of Battle Creek stream flow away from hydro power generation are expected to have substantial beneficial effects on naturally reproducing salmonid populations in the watershed

Re evaluation of Coleman National Fish Hatchery

In further support of the Battle Creek restoration effort the Service initiated a Re evaluation Process of the Coleman NFH in 1999 The primary goal of the Coleman NFH Re evaluation Process is to objectively review all aspects of facility operations to assure the integration of hatchery operations with AFRP guided restoration efforts in Battle Creek This broad based Re evaluation process is in addition to the ongoing hatchery evaluation programs (e g biological investigations and hatchery ESA permitting (Section 7 and 10)) conducted by the Service s Northern Central Valley Fish & Wildlife Service Office in Red Bluff The four major components of the Re evaluation Process are

1) Compilation and analysis of historical hatchery operations and evaluation work
2) Determination of mitigation responsibilities
3) Impact analyses of current and proposed production programs on listed stocks of anadromous salmonids
4) Identify potential hatchery management/operational alternatives that support fulfillment of hatchery mitigation responsibilities concurrent with restoration of Battle Creek

To this point substantial progress has been made towards each of these four main objectives Compilation and analysis of historical hatchery operations (Objective #1) and analysis of impacts of hatchery production programs (Objective #3) are nearly completed with most of the work conducted during preparation of the draft Hatchery and Genetic Management Plan (HGMP) The determination of fishery losses resulting from construction of the Shasta Dam (Objective #2) has received considerable effort and will

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continue to be investigated to determine federal mitigation responsibilities including that portion to be produced at the Coleman NFH Lastly 56 management/operational alternatives (Objective #4) were identified throughout the Coleman NFH Re-evaluation Process

Potential hatchery management/operational alternatives

A key aspect of the Re evaluation Process was the open forum type participation of the public and interested parties Approximately a dozen meetings were held between June 21 and September 16 1999 during which participants were invited to collaboratively identify potential impacts of current hatchery operations on natural salmonid stocks and identify alternative management/operational strategies to reduce or eliminate these impacts Technically focused aspects of hatchery operations where Coleman NFH activities may result in negative impacts to naturally produced salmonid populations were covered during seven topic specific subgroup meetings

1) Operation of the Coleman NFH barrier weir in Battle Creek
2) Trapping adults salmonids in the Coleman NFH barrier weir s upstream ladder
3) Broodstock collection at Battle Creek Keswick Dam and Red Bluff Diversion Dam
4) Broodstock selection spawning and genetic maintenance
5) Passage of excess steelhead above the barrier weir in Battle Creek
6) Juvenile releases
7) Water diversion and discharge

The participants in the subgroups assisted in developing 56 management alternatives covering each of these seven areas of potential hatchery impacts Many of the management alternatives suggested are very complex and will require additional concept development and/or extensive biological and engineering analyses (Attachment 1) Thorough analyses of these alternatives is necessary to determine their feasibility and applicability in promoting the integration of the hatchery with the AFRP guided restoration process in Battle Creek

Several management alternatives generated through the Coleman NFH Re evaluation Process will not be addressed by the awarded contractor (Attachments 2 & 3) Included in this group are A) alternatives that have already been implemented by the Service B) alternatives for which integration/improvements are already underway and, C) alternatives that will be addressed directly by the U S Fish and Wildlife Service

A) Alternatives which have already been fully implemented by Service

Some management alternatives suggested during the Coleman NFH Re-evaluation Process are quite simple and undisputable such as the addition of ice to broodstock transport trucks For some of these alternatives the Service has already taken actions to modify operations and reduce impacts to natural

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populations Detailed analysis of these alternatives is not necessary rather the Service will provide a description of management actions implemented to minimize potential impacts that will be incorporated into the final report by the awarded contractor

B) Alternatives for which integration/improvements are already underway
Several management alternatives generated during the Re evaluation Process pertain to activities at Coleman NFH for which substantial efforts have already been undertaken to integrate the hatchery with restoration of Battle Creek For example eleven different management alternatives dealt with modifications to the hatchery s barrier weir Many of these alternatives are currently being explored by an inter agency work group with technical representation in the areas of fish passage engineering biology and policy Complete re analysis of these alternatives is not necessary but rather a synopsis of the current status will be provided by the Service for incorporation into the final report by the awarded contractor

C) Alternatives that will be addressed directly by the U S Fish and Wildlife Service
Some of the management alternatives suggested during the Re evaluation Process are best responded to by the Service rather than the awarded contractor For example information describing the Service s role will be provided by the Service for incorporation into the report/s by the awarded contractor

Some alternatives will not be considered for implementation because they are outside the realm of actions that the Service will consider For example one suggested alternative was to maximize production at Coleman NFH at the expense of Battle Creek restoration This action will not be considered as it is not in alignment with goals of the AFRP ESA or the general mission of the Service and direction of the National Fish Hatchery System (letter from John G Rogers Acting Director USFWS, September 1 1999) Text clarifying that the Service is obligated to accomplish mitigation responsibilities in a manner that minimizes negative impacts on naturally produced stocks will be provided to the awarded contractor for incorporation into the draft report

Work to be performed:

Develop and analyze the management alternatives (Attachment 1) for their feasibility and potential impacts/benefits to natural production of chinook salmon and steelhead trout and Coleman NFH operations Thoroughly evaluate the impacts/benefits of proposed management alternatives to natural and hatchery production in regards to 1) natural stocks of salmon and steelhead in Battle Creek and the Sacramento River system 2) general ecosystem function in Battle Creek (as part of full restoration) and the Sacramento River system and 3) achieving production goals at the Coleman NFH

Task 1 Establish mailing lists to distribute information updates to the approximately 100 people interested in the Coleman NFH Re evaluation (e g Battle Creek Working Group and Battle Creek Watershed Conservancy) Both electronic list servers to e mail addresses and hard copy mailings to postal addresses can be used

Task 2 Describe each of the management alternatives (Attachment 1) in detail in some cases the alternative concept will need to be developed more fully Also describe similar procedures that are in place at other federal state and/or private hatcheries

Task 3 Prepare a draft list of references consulted for information

Task 4 Conduct an analysis of potential impacts for each alternative Provide two levels of analysis Scenario One Current Population Levels and Scenario Two Restored Population Levels For each level of analysis compare each alternative to current (baseline) operations and other alternatives The criteria used will include but will not be limited to

a) Effects on natural stocks of salmon and steelhead in Battle Creek and the Sacramento River system
b) Effects on the ability of the hatchery to achieve identified production objectives
c) Impact on general ecosystem function in Battle Creek (as part of full restoration) and the Sacramento River system

In each case potential impacts of each alternative will be described as strongly positive positive neutral or negative or strongly negative Include an analysis of risk to natural and hatchery populations should the proposed alternative fail

Task 5 Prepare a progress report on the status of the analysis of the hatchery management alternatives and distribute it to the people interested in CNFH Re evaluation (see task 1)

Task 6 Analyze and document the economic feasibility of implementing the management alternatives

Task 7 Assess and document the time required to implement the management alternatives

Task 8 After consulting with the appropriate Service contact/s incorporate the text provided by the Service for the management alternatives with integration/improvements underway (Attachment 2) and the alternatives that are being addressed directly by the Service (Attachment 3)

Task 9 Distribute the draft documents produced as a result of Tasks 2 8 to the people interested in CNFH Re evaluation Conduct a public meeting/workshop to clarify the additional analyses hear comments and invite additional information Invite further written comments within a 30 day time frame

Task 10 Incorporate comments conduct any additional analysis and prepare a draft final report on tasks 1 9 Distribute to stakeholders and FWS staff three weeks prior to the final review meeting

Task 11 Conduct a final review meeting Collect any remaining comments

Task 12 Incorporate comments Prepare and distribute approximately 100 copies of the final report (including literature citations)

Methods

- Develop an Interested Parties list Utilize this list (electronic and hard copy) to distribute products gather information and solicit feedback
- Due to the ongoing dynamic nature of some of these activities (e g Task 8) the draft reports will necessitate the inclusion of status updates The final report will need to reflect current (within 30 days) status of these projects
- If any alternatives are identified as possible to be combined separated or infeasible note this for later description in the final report
- Extensive consultations with Service and non Service biologists/management may be necessary to accurately assess impacts on natural stocks and Coleman NFH operations
- Service biologists will provide the information needed for Task 8 prior to the eighth month of the contract

Deliverables:

Detailed reports (including literature citations) describing the management alternatives and outlining the findings of the analysis

Project time frame:

FY 2000 funds will be used for this project The approximate time line is Task 1 during the first month Task 5 completed prior to the fifth month of the project Task 7 completed prior to the seventh month of the project and Task 10 completed prior to the eleventh month of the project The full project will need to be completed (Tasks 1 12) by November 30 2001

Attachments

#1 Management Alternatives requiring development and analysis through this contract

#2 Management Alternatives for which integration/improvements are underway

#3 Management Alternatives to be addressed directly by the U S Fish and Wildlife Service

Attachment 1) Management alternatives requiring development and analyses through this contract

Area of Concern	Alternative
Run Differentiation	
A1 1)	Mark/tag early arriving fall chinook to differentiate from spring chinook
Hatchery Discharge	
A1 2)	Routing discharge water from Coleman NFH through a seasonal wetlands before returning to Battle Creek
A1 3)	Routing discharge water from Coleman NFH through a seasonal wetlands and then through Govers ditch (for purpose of eliminating gover ditch water intake)
A1 4)	Routing discharge water from Coleman NFH through a seasonal wetland and then through Govers ditch (for purpose of isolating Coleman NFH from Battle Creek)
Fry Production Programs	
A1 5)	Release steelhead fry in tributaries to the Sacramento River to re establish natural populations
A1 6)	Utilize hatch box rearing strategies to re establish salmon populations in tributaries to the Sacramento River
A1 7)	Utilize hatch box rearing strategies to re establish steelhead populations in tributaries to the Sacramento River
Release Strategies	
A1 8)	Incorporate a volitional release strategy at Coleman NFH
A1 9)	Release fish based on physiological readiness rather than a pre determined timing schedule
A1 10)	Release steelhead in the fall rather than the spring
A1 11)	Modify schedule of juvenile releases to avoid impact at GCID
A1 12)	Release juvenile steelhead upstream in Battle Creek & tributaries to Battle Creek
A1 13)	Alternative release strategies for steelhead including release timing
A1 14)	Alter release numbers or timing based on conditions in the Sacramento River delta or ocean
A1 15)	Use Govers ditch as an alternative release point for fall chinook juveniles
Location of Coleman NFH on Battle Creek	
A1 16)	Move steelhead and/or late fall chinook production programs to a mainstem rearing facility
A1 17)	Move summer production of steelhead and/or late fall chinook to a mainstem rearing facility

Attachment 1) Management alternatives requiring development and analyses through this contract

Area of Concern	Alternative
Broodstock Collection	
A1 18)	Utilize Keswick trap to collect broodstock and decrease collections at the Coleman NFH (ie Multiple broodstock collection locations)
A1 19)	Utilize multiple off Battle Creek locations for broodstock collections (e g Keswick Red Bluff Gover ditch and others) for purpose of minimizing effects on Battle Creek
A1 20)	Move mainstem collection location of winter chinook broodstock from RBDD to ACID
Fall chinook over escapement to Battle Creek	
A1 21)	Remove carcasses from lower Battle Creek (for purpose of disease control)
A1 22)	Remove adults from lower Battle Creek for purposes of 1) reducing blockage of hatchery ladder 2) reducing false attraction into Battle Creek 3) reducing superimposition 4) reducing density dependent mortality of juveniles in lower Battle Creek
Barrier Weir Fish Trap	
A1 23)	Permit extended passage through the upstream ladder at the Barrier Weir
A1 24)	Permit passage at the barrier weir at the same time as collection of hatchery broodstock
A1 25)	Permit periodic passage at the barrier weir (intermittent with periods of broodstock collection)
A1 26)	Year round operation of the ladder through adaptive management
A1 27)	Construct a sorting facility in the barrier weir
Utilization of excess hatchery origin steelhead	
A1 28)	Re locate excess hatchery origin steelhead further upstream to increase the probability of successful spawning/survival of offspring
A1 29)	Re locate excess short steelhead to underpopulated streams
Hatchery Operations	
A1 30)	Modify spawn timing to create separation between runs (especially spring and fall) to avoid hybridization
Stand alone Alternatives	
A1 31)	Initiate a program to artificially propagate spring chinook salmon

Attachment 2) Management alternatives for which integration/improvements are already underway

Area of Concern **Alternative**

Collection of hatchery broodstock at the fish trap at Red Bluff Diversion Dam

A2 1) Decrease temperature differences between river and transport truck

Coleman NFH Intakes

A2 2) Reduce entrainment at the Coleman NFH intake diversions

A2 3) Avoid re directed impacts due to changes in diversions

Barrier Weir Fish Trap

A2 4) Replace the barrier weir with a movable weir

A2 5) Construct a fish tight barrier weir (removable or permanent)

A2 6) Construct a new fish ladder to meet ratio of streamflow criteria

A2 7) Complete re design of barrier weir fish trap integrated with the newly designed fish ladder

Hatchery Operations

A2 8) Change the percentage of jacks/shorts utilized as hatchery broodstock

A2 9) Integrate natural elements (e g NATURES rearing strategies) into hatchery fish culture operations

Attachment 3) Management alternatives to be addressed directly by the US Fish and Wildlife Service

Area of Concern	Alternative
Collection of hatchery broodstock at the fish trap at Red Bluff Diversion Dam	
A3 1)	Modify handling procedures to eliminate exposure of gills to air
A3 2)	Do not collect seriously injured fish as broodstock
Run Differentiation	
A3 3)	Mark and/or tag all fall chinook
Fry Production Programs	
A3 4)	Release salmon fry in tributaries to the Sacramento River to re establish natural populations
A3 5)	Re institute fry production program
Release Strategies	
A3 6)	Truck & release IHN infected fish early
Barrier Weir Fish Trap	
A3 7)	Reduce handling at the barrier weir fish trap
A3 8)	Extend hours of trap operations to minimize duration the trap acts as a barrier
Off-site Rearing	
A3 9)	Rear juvenile salmon in the bay/delta region to accomplish mitigation objective and reduce impacts of the hatchery to Battle Creek/Sacramento River
A3 10)	Release juvenile salmon in the Bay/delta to reduce impacts caused by upstream releases
Stand alone Alternatives	
A3 11)	Maximize hatchery production at the expense of restoration
A3 12)	Manage the hatchery primarily to accomplish restoration of Battle Creek (possibly foresaking production)
A3 13)	Replace the pre release pond with raceways
A3 14)	Change the fall or late fall programs to a supplementation program
A3 15)	Change the steelhead program to a supplementation program
A3 16)	Move Coleman NFH to a location other than Battle Creek

Attachment 4 1 Summary of fish salvage operations at the sand trap at Coleman National Fish Hatchery

Author: Dan Free <Dan Free@noaa gov> at -internet
Date: 02/19/1999 5:48 PM
Normal
TO: John T Nelson at _PO-MAIN Scott Hamelberg at 1PO-MAIN
Subject: Summary of sand trap salvage

---- ------ ------ -- ----- Message Contents

On 1/6 and 1/7 I conducted fish salvage in the Coleman NFH sand traps with the assistance of JamieCalloway and Will Me es The north basin was the first to be salvaged and began on 1/5 with the initiation of draining A small amount of water was left on to provide flushing It was thought that by lowering pond slowly while providing some outflow fish would volitionally leave the basin On 1/6 I donned waders and entered basin to look for fish Results were

1 chinook 116mmFL 126mmTL(winter run?)
1 tule perch
4 sacramento sucker
1 sacramento pikeminnow

In addition numerous other small (20mm?) non salmonid fish were observed but not salvaged as well as numerous lamprey ammocoetes(sp?) One dead riffle sculpin was found Numerous raccoon and bird tracks were visible

On 1/7 the drain was opened on the south basin at approximately 7:30 am I donned wetsuit and snorkeled length of sand trap Numerous small unidentifiable fish were observed Aquatic vegetation was abundant In addition I snorkeled the outflow from the basin but only observed one rainbow trout approximately 12"-probably not from sand trap After the basin drained numerous lamprey and small unidentified non-salmonids were observed

Overall success of salvage effort is undetermined Number of fish that left the trap during draining is unknown There is likely significant predation occurring once fish are entrained in the system Numerous piscivorous avian species are constantly observed in the water or adjacent shore of the sand traps Salvage of only one salmon should not be construed as evidence of limited entrainment Although obviously not an ESA concern the presence of large numbers of non-salmonids including lamprey should be considered when designing a salvage plan

Dan

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Coleman National Fish Hatchery
24411 Fish Hatchery Rd
Anderson CA 96007

May 14 1999

Subject Results of Fish Salvage efforts in CNFH Ditch

On May 13 1999 at 08 30 am the siphon on the Coleman National fish Hatchery ditch was close for the annual cleaning During this draw down the hatchery had 3 member of the crew try to salvage any endangered fish species that could have been trasped in the ditch Using the Frank Fisher size table to identify possible endangered Chinook Salmon that could be found in the ditch the 3 member salvage team worked all day walking the ditch at least 4 times and driving the surface road an additional six or seven times The only small fish found were hard heads or squaw fish There were <60 trout seen in the deep center of the ditch that could not be reached by the 20 foot dip nets being used The team did encounter problems when they tried to net the fish they would hid in the aquatic plant life growing in the ditch It was also decided by hatchery management that for safety reasons the crew was not to descend into the ditch because of the soft mud bottom and the large amount of silt that had been deposited in the ditch One of the crew members did try to salvage a trout and descended down the side of the ditch and sank to his knees before pulling himself out

It is reasonably believed that there were no endangered species in the Coleman NFH ditch at the time of draw down It is also believed that if any endangered spring chinook salmon were in the ditch that they did hid in the aquatic plants and their lost would be covered by the hatchery s incidental take permit

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Coleman National Fish Hatchery
24411 Fish Hatchery Rd.
Anderson CA 96007

August 16, 1999

National Marine Fisheries Service
ATTN Dan Free
777 Sonoma Avenue Room 325
Santa Rosa Ca 95404-6528

Dear Mr Free

The following is a description and report of the fish salvage which took place on August 9th and August 11th 1999 The drain plug to unit 2 was pulled at 0600 a m and this unit of the sand trap was allowed to drain all day Hatchery personnel were on site from 0600 hours for 12 hours until 6 p m that evening The salvage of 94 salmon and trout took place during this 12 hour period The fish were caught by angling cast net and seine nets as the water drained With your concurrence a tractor was used to cut a channel down the middle of unit 2 to ensure an escape passage for any fish that was not caught in 12 hours of salvaging Unit 2 of the sand trap was left open during the night to give any fish a chance to escape At 0700 hours on August 10th the drain plug was replaced in unit 2 and wash down of the sides began At 3 p m the afternoon of August 10 the drain plug was again removed to allow any fish that were not salvaged an escape route On August 11th the drain plug was replaced and unit 2 is being allowed to dry before removal of any material At this time ozone personnel discovered water seeping into unit 2 from two holes in the bottom of the trap and to prevent further damage unit 1 was drained on August 11th Starting at 0500 a m unit 1 was drained and salvaging began using the same procedures as were used in unit 2 During the draw down stage in unit 1 there were 84 trout and 4 salmon salvaged During both salvages the fish were placed in a holding tank until released into Battle Creek Attached are the forms used to ID and measure size of fish during salvaging

It should be noted that this was and exceptional year at Coleman NFH for the following reasons 1 There has been major construction going on the whole year at the ozone site 2 No high water or large amount of silt in the hatchery water 3 Cleaning of sand trap was 2 month behind schedule and 4 The large amount of submerged aquatic vegetation in both units of the sand trap

Sincerely

John R. Scott
Coleman NFH

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FISH COLLECTION SUMMARY MAY 24 JULY 13 2000

SPECIES	NUMBER	LENGTH RANGE (MM)
Suckers	2841	
Salmon	782	97-206
Trout	749	25-370
Unknown	644	90-155
Northern Pikeminnow	62	
Sculpins	37	
Tule Perch	18	
Green Sunfish	16	
Lampreys	16	
California Roach	3	
Crayfish	1	
Total	5169	

Procedure.

At approximately 6 a m the draw down of Sand Trap No 1 was initiated By 9:30 a m water depth had dropped to 2 5 feet and the drain valve was closed In flow valves were opened to attract fish to the upper end of the basin Beginning roughly 40 to 50 feet from the inflow a beach seine was inserted and pulled toward the water source Fish were captured within the seine using dip nets. This process was repeated two more times At 2:00 p m. seining operations ceased and a center channel was cut the length of trap Inflow water was turned on On July 13 2000 the same procedures were followed for Sand Trap No 2 This was done to allow remaining fish an escape route to outflow channel which empties into Battle Creek

COLEMAN NFH: FISH SALVAGE SUMMARY REPORT

The following report is for fish salvage operations performed in the carbon filtration beds (May 24 and 31 2000), Coleman Canal (June 8 and 9 2000) and the sand traps (July 12 and 13 2000)

Carbon Filtration Beds:

On May 24 and May 31 2000 a total of 644 fish ranging in length from 90 to 155 mm, were removed from filter beds No 1 and No 2 Bed No 3 was salvaged earlier but no data was collected

Procedures:

Water levels were lowered to approximately three inches from the top of the beds Utilizing dip nets personnel proceeded to capture fish now confined to a single filtration cell This procedure was repeated until all cells were cleared. The water levels were then further lowered to about three inches from the bottom of the bed itself Fish were then dip-netted and removed from the incoming water channel All netted fish were moved to an aerated transport tank and later released into Battle Creek

Species identification and length measurements will be performed on all future salvage operations

Coleman Canal:

On June 8 and 9 2000 salvage operations were performed in the Coleman Canal A total of 280 trout ranging in length from 25 to 370 mm were captured and released to Battle Creek. Twenty six salmon measured from 97 to 157 mm. Other species captured and released included Green sunfish Northern pikeminnow suckers lampreys Tule perch sculpins, and one crayfish

Procedures.

On June 7 2000 the canal draw-down process was initiated. That night, a small volume of water was left flowing through the canal On the day of the salvage (June 8 2000), an electro fishing specialist from the Northern California Valley FWO surveyed the 1/2mile canal and determined that there were six areas/sections that could be fished safely

Dowstream from the targeted area a beach seine was pulled upstream to the lower boundary A block net was then put in place and the seine removed This procedure was again performed, now pulling the seine downstream to the upper boundary of the target area

A second block was secured With the target area now confined electro fishing began Shocked fish were dip netted, identified measured and placed into and aerated transport tank. All fish were released into Battle Creek. This procedure was repeated for the remaining five target areas On day two (June 9 2000) the same six target areas were salvaged again using the same methods

This electro fishing process worked exceptionally well Most fish in the target areas were captured and shocking mortality was minimal

Sand Traps.

A total of 756 salmon and 469 trout were captured and removed from the sand traps on July 12 and 13 2000 The salmon ranged in length from 127 to 206 mm Other fish captured included Tule perch Northern pikeminnows lampreys sculpins and 2756 suckers

Attachment 4 2 Adopted waste discharge requirements for Coleman National Fish Hatchery (Order No 96 235 as adopted by the California Regional Water Quality Control Board)

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STATE OF CALIFORNIA Environmental Protection Agency PETE WILSON, Gove

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
415 Knollcrest Drive Suite 100
Redding CA 96002 0101
PHONE (916) 224-4845
FAX (916) 224-4857

8 October 1996

CERTIFIED MAIL
#P 331 022 278

Mr John T Nelson
U S Fish and Wildlife Service
Coleman Fish Hatchery
24411 Coleman Fish Hatchery Road
Anderson CA 96007

TRANSMITTAL OF ADOPTED WASTE DISCHARGE REQUIREMENTS FOR U S DEPARTMENT OF INTERIOR FISH AND WILDLIFE SERVICE COLEMAN FISH HATCHERY SHASTA COUNTY

Enclosed is an official copy of Order No 96 235 as adopted by the California Regional Water Quality Control Board Central Valley Region at its 20 September 1996 meeting

JAMES C PEDRI
Assistant Executive Officer

ALM djc

Enclosures Adopted Order
Standard Provisions
Proposition 65 Information

cc U S Environmental Protection Agency Region 9 San Francisco (with Adopted Order)

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO 96 235

NPDES NO CA0004201

WASTE DISCHARGE REQUIREMENTS
FOR
U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
COLEMAN FISH HATCHERY
SHASTA COUNTY

The California Regional Water Quality Control Board Central Valley Region (hereafter Board) finds that

1 The U S Department of Interior Fish and Wildlife Service (hereafter Discharger) submitted a Report of Waste Discharge dated 19 March 1996 and applied for a permit revision to discharge waste under the National Pollution Discharge Elimination System (NPDES) from the Coleman-Fish Hatchery The Discharger has added a cooling water discharge from the ozone treatment facility

2 The Discharger owns and operates the flow through cold water Coleman Fish Hatchery The fish hatchery is on Assessor s Parcel Nos 057 540 03 and 057 540 04 north of Battle Creek three miles (4 8 km) south of the Balls Ferry Bridge on the Sacramento River in Section 1 T29N R3W MDB&M as shown on Attachment A a part of this Order The Discharger utilizes water from Battle Creek and the Coleman Canal and discharges fish hatchery wastewater to Battle Creek Battle Creek is a water of the United States and a tributary of the Sacramento River

3 The facility discharges an average of 40 8 mgd of fish hatchery flow through wastewater and rears 200 000 pounds of chinook salmon and 150 000 pounds of steelhead trout annually Currently the facility s design maximum is 65 0 mgd The Discharger has installed a sand trap a sand filter and an ozone treatment facility to reduce the level of settleable solids and pathogens in the Battle Creek water supply prior to contact with hatchery fish Approximately 24 0 mgd of the facility s water supply by passes the fish rearing operations during normal conditions Approximately 0 4 mgd of cooling water is discharged into the by pass channel from the ozone treatment building The by pass channel flows into Battle Creek at Discharge 001 Approximately 37 1 mgd of wastewater from the hatchery building and the upper and lower raceways discharges to Battle Creek at Discharge Point 002 Approximately 3 3 mgd of wastewater is diverted to a Pollution Abatement settling pond during raceway cleaning/treatment of eggs The settling pond discharges to Battle Creek at

Discharge Point 003 The facility flows are shown on Attachment B a part of this Order

4 Chemical usage at the hatchery is primarily a disease preventative measure Ozone treatment of the water supply has decreased the need for chemical usage Malachite green salt and antibiotics are among the chemicals used to treat adult fish An iodine solution and formalin are used to treat eggs for fungus MS 222 is used as an anesthetic and luteinizing hormone releasing hormone is used to control reproductive cycles in female fish Chloramine T hyamine and hydrogen peroxide are used as disinfectants Use of malachite green as a fungicide and parasiticide in fish culture operations in California is prohibited except where the U S Food and Drug Administration grants an Investigational New Animal Drug (INAD) exemption This exemption must be obtained on an annual basis whenever the use of malachite green is proposed Where an INAD exemption has been granted water containing malachite green must be treated by passage through two in series 2 000 pound Granular Activated Carbon (GAC) canisters prior to discharge into other wastewater flows

5 Existing wastewater treatment technology (such as settling basins and GAC canisters) is capable of consistently reducing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or groundwater are adversely affected

6 Approximately twenty employees work on site with five individuals living on site Domestic wastewater is discharged from the residences and hatchery buildings to three septic tank/leachfield systems

7 The facility currently has a 4 000 gallon aboveground tank for diesel to operate standby generators and a 500 gallon aboveground tank for gasoline Neither tank has secondary containment at this time However a contract which is underway provides for the removal of the 4 000 gallon tank installation of two new tanks (300 and 500 gallons respectively) and construction of concrete containment for all aboveground tanks Once the new petroleum storage facilities are in place the total storage capacity will be 800 gallons of diesel and 500 gallons of gasoline

8 The U S Environmental Protection Agency (USEPA) and the Board have classified this discharge as a minor discharge

9 The Board has adopted a Water Quality Control Plan Third Edition for the Sacramento River Basin and the San Joaquin River Basin (hereafter the Basin Plan)

which contains water quality objectives for all waters of the Basins These requirements implement the Basin Plan

10 Federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have the reasonable potential to cause or contribute to an in stream excursion above a narrative or numerical water quality standard Based on information submitted as part of the application in studies and as directed by monitoring and reporting programs the Board finds that the discharge does not have a reasonable potential to cause or contribute to an in stream excursion above a water quality objective

11 The beneficial uses of Battle Creek downstream of the discharge are agricultural supply water contact and noncontact recreation esthetic enjoyment and preservation and enhancement of fish wildlife and other aquatic resources

12 The beneficial uses of the underlying groundwater are municipal and domestic supply agricultural supply industrial service supply and industrial process supply

13 The permitted discharge is consistent with the antidegradation provisions of 40 CFR 131 12 and State Water Resources Control Board (SWRCB) Resolution 68 16 The impact on existing water quality will be insignificant

14 Effluent limitations and toxic and pretreatment effluent standards established pursuant to Sections 301 302 304 and 307 of the Clean Water Act (CWA) and amendments thereto are applicable to the discharge

15 This discharge is presently governed by Waste Discharge Requirements Order No 93 229 adopted by the Board on 3 December 1993

16 The action to adopt an NPDES permit is exempt from the provisions of Chapter 3 of the California Environmental Quality Act (CEQA) (Public Resources Code Section 21100 et seq) in accordance with Section 13389 of the California Water Code

17 The Board has notified the Discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for this discharge and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations

18 The Board in a public meeting heard and considered all comments pertaining to the discharge

19 This Order shall serve as an NPDES permit pursuant to Section 402 of the CWA and amendments thereto and shall take effect upon the date of hearing provided EPA has no objections

IT IS HEREBY ORDERED that Order No 93 229 is rescinded and that the U S Department of Interior Fish and Wildlife Service its agents successors and assigns in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder and the provisions of the Clean Water Act and regulations and guidelines adopted thereunder shall comply with the following

A Discharge Prohibitions

1 Discharge of wastewater at a location or in a manner different from that described in Finding Nos 3 and 4 is prohibited

2 The by pass or overflow of untreated wastewater or wastes into any surface water or surface water drainage course is prohibited except as allowed by the attached Standard Provisions and Reporting Requirements A 13

3 Discharge of toxic or hazardous substances including petroleum products (except as provided in Discharge Specification C 1) is prohibited

B Effluent Limitations (Discharges 002 and 003)

1 Effluent shall not exceed the following limits

Constituent	Unit	Monthly Average	Daily Maximum
Total Suspended Solids[1]	mg/l	5	15
	lbs/day[2]	2 711	8 133
Settleable Solids	ml/l	0 1	0 2
Formaldehyde	mg/l	–	5

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[1] Effluent limitations are net values

[2] Based upon a design capacity of 65 0 mgd

2 The discharge shall not have a pH of less than 6 0 nor greater than 9 0

3 The maximum daily discharge shall not exceed 65 0 mgd

C Discharge Specifications (Malachite Green Treatment)

1 Water to which malachite green is added shall be treated prior to discharge by passage through GAC canisters The outflow from the canisters shall not exceed the following limit (as determined by using Waters C_{18} Sep Pak analysis or comparable method with a detection limit no greater than 10 µg/l)

Constituent	Unit	Average	Maximum
Malachite Green	µg/l		10

D Discharge Specifications (Domestic Wastewater)

1 The discharge shall not cause the degradation of any water supply

2 Neither the treatment nor the discharge shall cause a nuisance or conditions of pollution as defined by the California Water Code Section 13050

3 The domestic sewage discharge shall remain underground at all times and there shall be no direct discharge to surface waters or surface water drainage courses

4 Objectionable odors originating at this facility shall not be perceivable beyond the limits of the Discharger s property

E Solid Waste Disposal

1 Collected screening sludges and other solids including fish carcasses shall be disposed of in a manner approved by the Executive Officer

2 Any proposed change in solid waste disposal practice from a previously approved practice shall be reported to the Executive Officer at least 30 days in advance of the change

F Receiving Water Limitations

Receiving Water Limitations are based upon water quality objectives contained in the Basin Plan As such they are a required part of this Order

The discharge shall not cause the following in Battle Creek

1 Concentrations of dissolved oxygen to fall below 7 0 mg/l In the event the receiving waters are determined to have a dissolved oxygen concentration of less than 7 0 mg/l the discharge shall not depress the dissolved oxygen concentration below the background level

2 Oils greases waxes or other materials to form a visible film or coating on the water surface or on the stream bottom

3 Oils greases waxes floating material (liquids solids foams and scums) or suspended material to create a nuisance or adversely affect beneficial uses

4 Aesthetically undesirable discoloration

5 Fungi slimes or other objectionable growths

6 Turbidity to increase more than 20% over background levels

7 The normal ambient pH to fall below 6 5 exceed 8 5 or change by more than 0 5 units

8 The normal ambient temperature to be altered by more than 5 F

9 Deposition of material that causes nuisance or adversely affects beneficial uses

10 Taste or odor producing substances to impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin or to cause nuisance or adversely affect beneficial uses

11 Radionuclides to be present in concentrations that exceed maximum contaminant levels specified in the California Code of Regulations (CCR) Title 22 that harm human plant animal or aquatic life or that result in the accumulation of

radionuclides in the food web to an extent that presents a hazard to human plant animal or aquatic life

12 Aquatic communities and populations including vertebrate invertebrate and plant species to be degraded

13 Toxic pollutants to be present in the water column sediments or biota in concentrations that adversely affect beneficial uses that produce detrimental response in human plant animal or aquatic life or that bioaccumulate in aquatic resources at levels which are harmful to human health

14 Violation of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board pursuant to the CWA and regulations adopted thereunder

G Groundwater Limitations

The domestic sewage shall not cause underlying groundwater to

1 Be degraded

2 Exceed a most probable number of total coliform organisms of 2 2/100 ml over any 7 day period

3 Contain taste or odor producing substances in concentrations that cause nuisance or adversely affect beneficial uses

H Provisions

1 The Discharger must comply with all conditions of this Order including timely submittal of technical and monitoring reports as directed by the Executive Officer Violations may result in enforcement action including Regional Board or court orders requiring corrective action or imposing civil monetary liability or in revision or rescission of this Order

2 A copy of this Order shall be kept at the discharge facility for reference by operating personnel Key personnel shall be familiar with its content

3 The Discharger shall comply with the standards contained in the Health and Safety Code Chapter 6 67 *Aboveground Storage of Petroleum* and any amendments thereto

4 The Discharger shall use the best practicable cost effective control technique currently available to limit mineralization to no more than a reasonable increment

5 The Discharger shall comply with all the items of the Standard Provisions and Reporting Requirements for Waste Discharge Requirements (NPDES) dated 1 March 1991 which are part of this Order This attachment and its individual paragraphs are referred to as Standard Provision(s)

6 The Discharger shall comply with the Monitoring and Reporting Program No 96-235 which is part of this Order and any revisions thereto as ordered by the Executive Officer

When requested by USEPA the Discharger shall complete and submit Discharge Monitoring Reports The submittal date shall be no later than the submittal date specified in the Monitoring and Reporting Program for Discharger Self Monitoring Reports

7 This Order expires on **1 September 2001** and the Discharger must file a Report of Waste Discharge in accordance with Title 23 CCR not later than **180 days** in advance of such date in application for renewal of waste discharge requirements if it wishes to continue the discharge

8 Prior to making any change in the discharge point place of use or purpose of use of the wastewater the Discharger shall obtain approval of or clearance from the SWRCB Division of Water Rights

9 In the event of any change in control or ownership of land or waste discharge facilities presently owned or controlled by the Discharger the Discharger shall notify the succeeding owner or operator of the existence of this Order by letter a copy of which shall be immediately forwarded to this office

To assume operation under this Order the succeeding owner or operator must apply in writing to the Executive Officer requesting transfer of the Order The request must contain the requesting entity s full legal name the state of incorporation if a corporation the name address and telephone number of the persons responsible for contact with the Board and a statement The statement shall comply with the signatory paragraph of Standard Provision D 6 and state that the new owner or operator assumes full responsibility for compliance with this Order Failure to submit the request shall be considered a discharge without requirements a violation of the California Water Code Transfer shall be approved or disapproved in writing by the Executive Officer

I WILLIAM H CROOKS Executive Officer do hereby certify the foregoing is a full true and correct copy of an Order adopted by the California Regional Water Quality Control Board Central Valley Region on 20 September 1996

William H Crooks
WILLIAM H CROOKS Executive Officer

ALM djc

Attachments

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

MONITORING AND REPORTING PROGRAM NO 96 235

NPDES NO CA0004201

FOR
U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
COLEMAN FISH HATCHERY
SHASTA COUNTY

WATER SUPPLY MONITORING

A sampling station shall be established and located where representative samples of the water supply from above the facility can be obtained Samples shall be collected at approximately the same time as monthly effluent samples Water supply monitoring shall include at least the following

Constituent	Unit	Type of Sample	Sampling Frequency
Total Suspended Matter	mg/l	8 Hr Composite	Monthly
Settleable Matter	ml/l	Grab	Monthly
pH	number	Grab	Monthly
Dissolved Oxygen	mg/l	Grab	Monthly
Turbidity	NTU	Grab	Monthly
Temperature	C	Grab	Monthly

EFFLUENT MONITORING

Discharges 002 and 003

Effluent samples shall be collected immediately downstream from the last connection through which wastes can be admitted into the outfall Samples shall be collected during cleaning of raceways or during administration of chemical treatments and should be representative of the volume and quality of the discharge at that time Time of collection of samples shall be recorded Effluent monitoring shall include the following

Constituent	Unit	Type of Sample	Sampling Frequency
Total Suspended Matter	mg/l lbs/day	8 Hr Composite	Monthly
Settleable Matter	ml/l	Grab	Monthly
pH	number	Grab	Monthly
Flow	mgd		Monthly
Formaldehyde	mg/l	Grab	Monthly[1]

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[1] During those months when formaldehyde is added to waters at the facility in concentrations of 1 part per million or greater (for example when 1 gallon or more of formaldehyde is added to a 1 million gallon flow)

MALACHITE GREEN MONITORING

When malachite green is added to a portion of the hatchery flow and the flow is subsequently treated by passage through the granular activated carbon (GAC) canisters the outflow from the canisters shall be monitored The monitoring shall consist of at least the following

Constituent	Units	Type of Sample	Sample Frequency
Malachite Green	µg/l	Grab	Monthly

RECEIVING WATER MONITORING

All receiving water samples shall be grab samples Receiving water samples shall be collected at a depth of 6 to 12 inches below the surface at the following stations

Station	Description
R 1	25 feet upstream from the point where Discharge 001 flows into Battle Creek
R 2	25 feet downstream from the point where Discharge 002 flows into Battle Creek
R 3	25 feet downstream from the point where Discharge 003 flows into Battle Creek

Constituent	Unit	Station	Sampling Frequency
Dissolved Oxygen	mg/l	all	Monthly
Turbidity	NTU	all	Monthly
Temperature	C	all	Monthly
pH	number	all	Monthly

Receiving water samples shall be collected at approximately the same time as the effluent samples In conducting the receiving water sampling a log shall be kept of the receiving water conditions throughout the reach bounded by Stations R 1 through R 3 Attention shall be given to the presence or absence of

a Floating or suspended matter
b Discoloration
c Bottom deposits
d Aquatic life
e Visible films sheens or coatings
f Fungi slimes or objectionable growths
g Potential nuisance conditions

Notes on receiving water conditions shall be summarized in the monitoring report

SEPTIC TANK MONITORING AND INSPECTIONS

Septic tank maintenance inspections (including tank sludge level measurement) shall be performed at least once per year Information concerning inspections and maintenance activities (including but not limited to pumping replacement and repairs) shall be included in the monitoring reports submitted to the Board

LEACHFIELD MONITORING

The Discharger shall inspect the leachfield areas weekly and submit the results in the monitoring report Monitoring shall include any observations of seeps erosion field saturation ponding liquid the presence of nuisance and other field conditions

REPORTING

Monthly monitoring reports shall be submitted to the Regional Board by the **15th day** of the month following sample collection A daily log shall be maintained of the quantities of all chemicals used for anesthetic disease control disinfection and all other hatchery operations which result in chemicals becoming constituents of the discharge This information shall be submitted monthly as part of the monitoring report

In reporting the monitoring data the Discharger shall arrange the data in tabular form so that the date the constituents the concentrations and the sampling points are readily discernible The data shall be summarized in such a manner as to clearly illustrate the compliance with waste discharge requirements

If the Discharger monitors any pollutant at the locations designated herein more frequently than is required by this Order he shall include the results of such monitoring in the calculation and reporting of the values required in the discharge monitoring report form Such increased frequency shall be indicated on the discharge monitoring report form

By 31 October each year the Discharger shall submit a written annual report to the Executive Officer containing the following information

a The names and telephone numbers of persons to contact regarding the facility for emergency and routine situations

b A table showing the quantities (in pounds grams or gallons) of all chemicals used during the previous production year

c The total pounds of fish food used during the previous production year and the pounds of fish produced

The production year shall be defined as the period of time between 1 October and 30 September

The Discharger may also be requested to submit an annual report to the Board with both tabular and graphical summaries of the monitoring data obtained during the previous year Any such request shall be made in writing The report shall discuss the compliance record If violations have occurred the report shall also discuss the corrective actions taken and planned to bring the discharge into full compliance with the waste discharge requirements

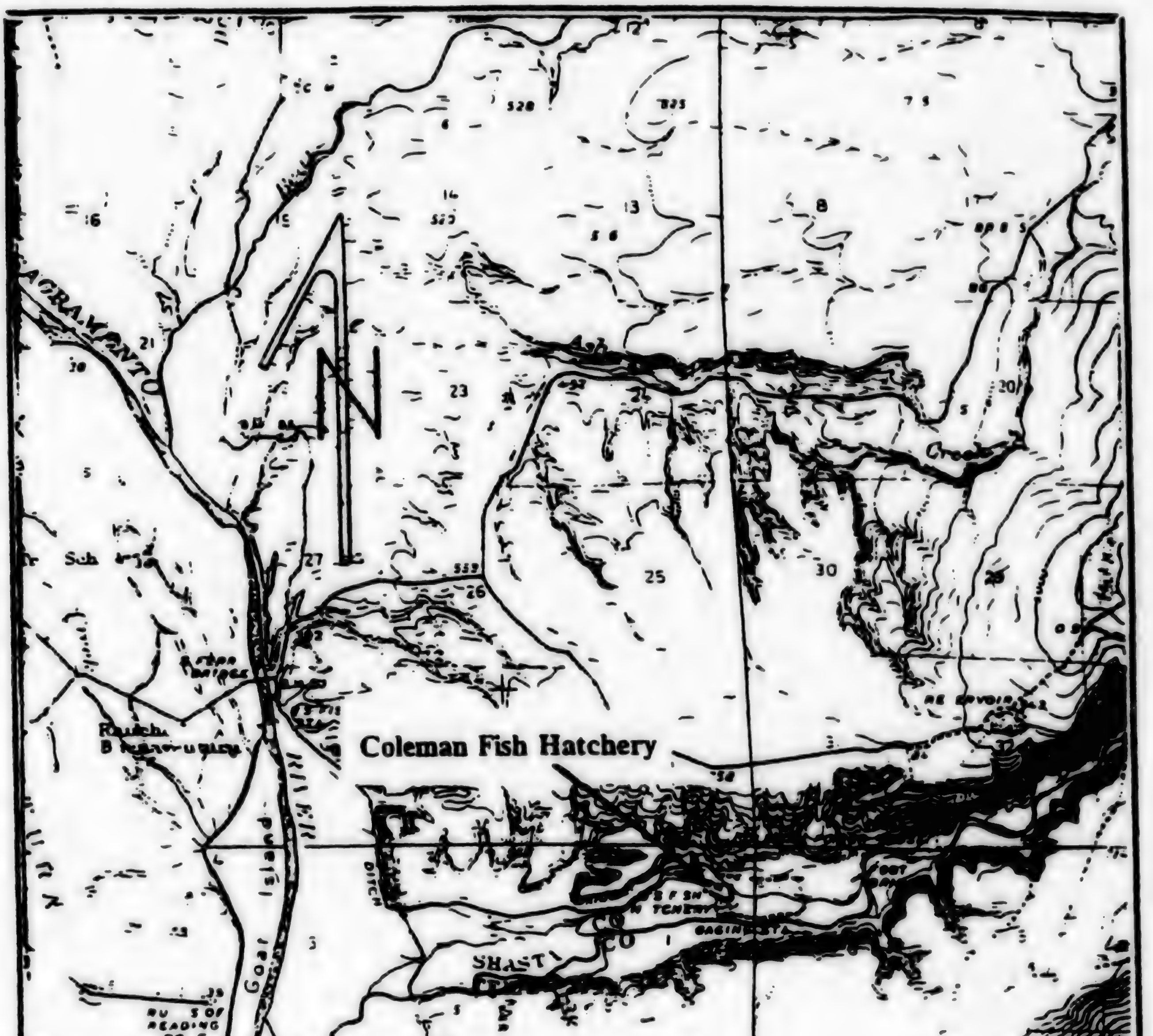
All reports submitted in response to this Order shall comply with signatory requirements of Standard Provision D 6

Ordered by William H Crooks
WILLIAM H CROOKS Executive Officer

20 September 1996
(Date)

ALM djc

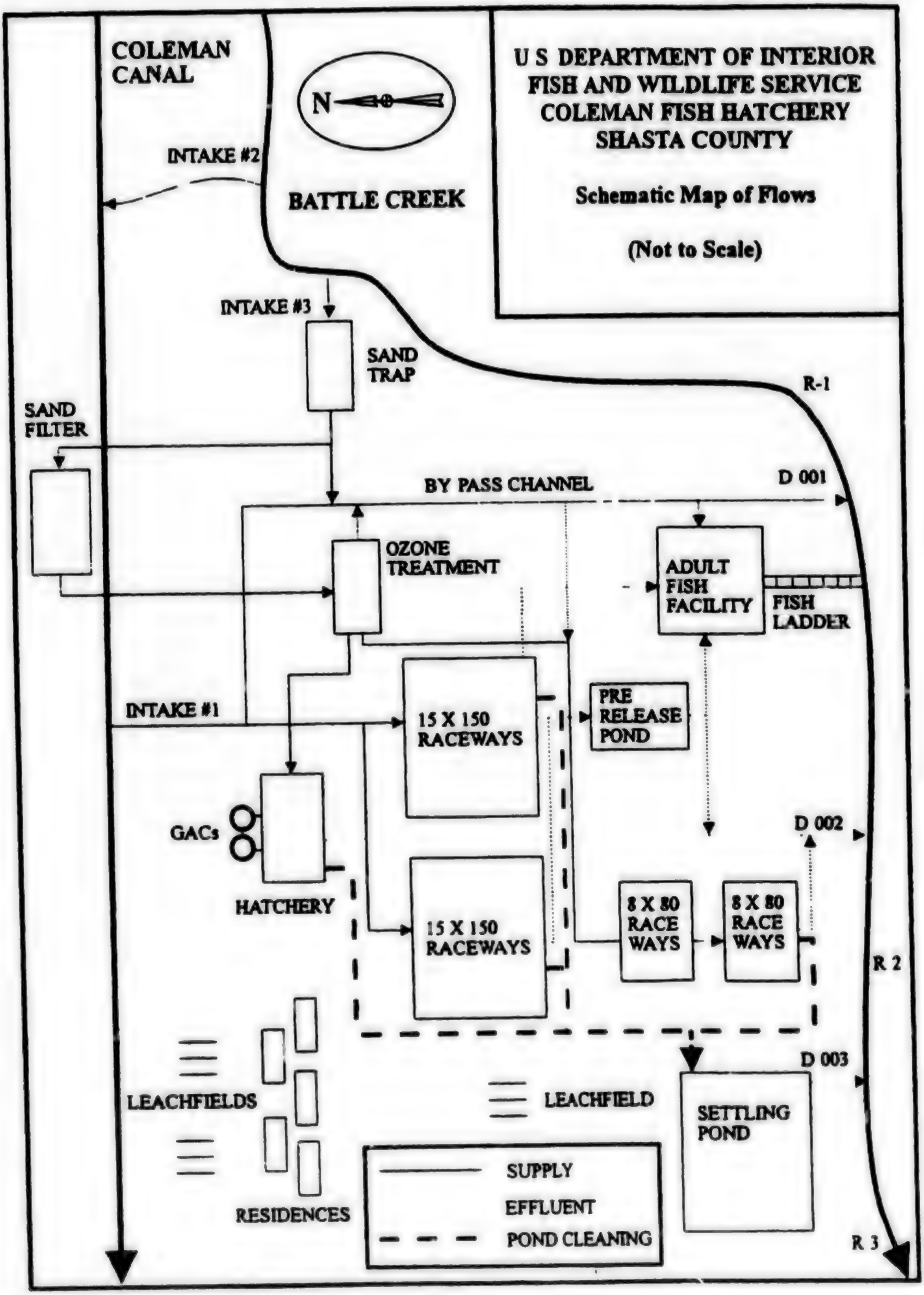
ATTACHMENT A



U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
COLEMAN FISH HATCHERY
SHASTA COUNTY

Section 1 T29N R3W MDB&M
Tuscan Buttes CA 15 USGS Quad
Scale: 1 inch = 1 Mile

ATTACHMENT B



INFORMATION SHEET

U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
COLEMAN FISH HATCHERY
SHASTA COUNTY

The Coleman Fish Hatchery owned and operated by the U S Fish and Wildlife Service is south of Anderson on Battle Creek a tributary of the Sacramento River Facilities consist of an administration building 5 residences a maintenance building a spawning building an ozone treatment facility 58 raceways 3 holding ponds and a fish ladder

The hatchery produces a yearly average of 350 000 pounds of chinook salmon and steelhead trout utilizing concrete raceways which require a constant source of high quality water Hatchery water is derived from Battle Creek and the Coleman Canal The facility has a Hatchery Development Plan with a final design treatment capacity of 93 6 mgd with an average discharge of 40 8 mgd and maximum of 65 mgd at this time Since 1987 the Discharger had operated a large sand trap/sand filter system capable of treating 20 000 gpm of the water supply prior to hatchery use That treatment has reduced the settleable materials entering the hatchery thereby resulting in an overall reduction in settleable materials discharged to Battle Creek the receiving water In 1996 the Discharger installed an ozone treatment system to avoid the introduction of pathogens endemic to the water supply into the hatchery operation The ozone treatment requires approximately 300 gpm of cooling water This water is heated to an average of 10 F over the baseline temperature (to approximately 67 F) and is discharged to the by pass channel which discharges to Battle Creek (Discharge 001)

Wastes discharged from the rearing operations include fish fecal material unconsumed food algae and silt Battle Creek receives 37 1 mgd of flow through hatchery wastewater from the upper and lower raceways (Discharge 002) Generally raceways that are in use are cleaned on a daily basis during the work week During raceway cleaning an average of 3 3 mgd of hatchery wastewater are diverted to a single Pollution Abatement settling pond The discharge from the Pollution Abatement pond enters a drainage ditch to Battle Creek (Discharge 003)

Based on a USEPA study to assess best practical and best conventional treatment technologies flow through ponds should achieve total suspended solids concentrations of less than 5 0 mg/l Past monitoring data indicate this facility achieves the effluent limitations that represent the application of USEPA Best Conventional Technology The requirements have been revised to reflect current operations and needed monitoring The requirements contain effluent limitations for total suspended matter and settleable matter

Chemical usage at the hatchery is primarily a disease preventative measure Ozone treatment of the water supply has decreased chemical usage at the hatchery Chemicals used include salt feed antibiotics MS 222 argentine (an iodine solution) hyamine chloramine T hydrogen peroxide formaldehyde and malachite green Salt is used to reduce stress the antibiotics treat various bacterial infections and MS 222 is an anesthetic Argentine hyamine chloramine T and hydrogen peroxide are all disinfectants Formaldehyde is used as a fungicide treatment for fish eggs during incubation These requirements contain an effluent limitation of 5 0 mg/l for formaldehyde based on the USEPA s Health Advisory for 10 day acute exposure Malachite green is a fungicide and parasiticide Its use in fish culture operations in California is prohibited except where the U S Food and Drug Administration grants an Investigational New Animal Drug (INAD) exemption Where an INAD exemption has been granted all water contaminated by malachite green must be treated by passage through two in series 2 000 pound granular activated carbon (GAC) canisters prior to discharge into other wastewater flows

The Board has determined that acute toxicity effluent limits are not needed in this permit as this is an aquatic production facility raising larval fish through sensitive critical life stages and this can be representative of a continuous bioassay For the same reason three species chronic biotoxicity testing is not being required

The facility currently has a 4 000 gallon aboveground tank for diesel to operate standby generators and a 500 gallon aboveground tank for gasoline Neither tank has secondary containment at this time However a contract which is underway provides for the removal of the 4 000 gallon tank installation of two new tanks (300 and 500 gallons respectively) and construction of concrete containment for all aboveground tanks Once the new petroleum storage facilities are in place the total storage capacity will be 800 gallons of diesel and 500 gallons of gasoline

Domestic sewage from the residences and hatchery buildings is discharged to three septic tank/leachfield systems

ALM djc 9/20/96

Attachment 4 3 **Waste discharge requirements for Livingston Stone National Fish Hatchery (Winter Run Rearing facility) Shasta County (NPDES No CA0084298)**

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO

NPDES NO CA0084298

WASTE DISCHARGE REQUIREMENTS FOR U S DEPARTMENT OF INTERIOR FISH AND WILDLIFE SERVICE AND U S BUREAU OF RECLAMATION WINTER RUN REARING FACILITY SHASTA COUNTY

The California Regional Water Quality Control Board Central Valley Region (hereafter Board) finds that

1 The U S Department of Interior Fish and Wildlife Service submitted a Report of Waste Discharge dated 30 October 1997 to discharge waste under the National Pollutant Discharge Elimination System (NPDES) from a new aquaculture facility

2 The property (Assessor s Parcel No 065-510-01 11) and facility are owned by the Bureau of Reclamation The Fish and Wildlife Service will operate the facility The Fish and Wildlife Service and the Bureau of Reclamation are designated hereafter as the Discharger The facility is 1/2 mile downstream of the Shasta Dam powerhouse approximately 3 miles northwest of the City of Shasta Lake in Section 15 T33N R5W MDB&M as shown on Attachment A a part of this Order The Discharger diverts water from the Shasta Dam penstocks and discharges wastewater to the Sacramento River a water of the United States

3 The Winter Run Rearing facility has a projected average annual production of 16 000 pounds of juvenile and broodstock winter run chinook salmon The Discharger discharges a maximum of 7 2 mgd of fish hatchery wastewater Wastewater from 52 circular and rectangular tanks will be discharged through one of two discharge points (Discharge 001 and 002) to the Sacramento River Under normal conditions a portion of the water diverted from the penstock for the operation by passes the aquaculture facility and is discharged directly into the Sacramento River upstream of the facility The facility and Discharges 001 and 002 are shown on Attachment B a part of this Order

4 Chemical usage at the hatchery is primarily a disease preventative measure Malachite green formaldehyde salt oxytetracycline erythromycin and luteinizing hormone release hormone analog are among the chemicals used to treat fish Use of malachite green as a fungicide and parasiticide in fish culture operations in California is prohibited except where the U S Food and Drug Administration grants an

Investigational New Animal Drug (INAD) exemption This exemption must be obtained on an annual basis whenever the use of malachite green is proposed Where an INAD exemption has been granted water containing malachite green must be treated by passage through granular activated carbon (GAC) canisters prior to discharge into other wastewater flows

5 Existing wastewater treatment technology (such as settling basins) is capable of dependably removing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or groundwater are adversely affected

6 Domestic wastewater from the facility is discharged to a septic tank/leachfield system

7 The U S Environmental Protection Agency (USEPA) and the Board have classified this discharge as a minor discharge

8 The Board adopted a Water Quality Control Plan Third Edition for the Sacramento River Basin and the San Joaquin River Basin (hereafter Basin Plan) which designates beneficial uses establishes water quality objectives and describes an implementation program and policies to achieve those objectives for all waters of the Basin These requirements implement the Basin Plan

9 Federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have the reasonable potential to cause or contribute to an in-stream excursion above a narrative or numerical water quality standard Based on information submitted as part of the application in studies and as directed by monitoring and reporting programs the Board finds that the discharge does not have a reasonable potential to cause or contribute to an in-stream excursion above a water quality objective

10 The beneficial uses of the Sacramento River are municipal agricultural and industry water supply water contact and noncontact recreation esthetic enjoyment groundwater recharge freshwater replenishment hydroelectric power generation navigation and preservation and enhancement of fish wildlife and other aquatic resources

11 The beneficial uses of the underlying groundwater are municipal and domestic supply agricultural supply and industrial service and process supply

12 The permitted discharge is consistent with the antidegradation provisions of 40 CFR 131 12 and State Water Resources Control Board (SWRCB) Resolution 68 16 The impact on existing water quality will be insignificant

13 Effluent limitations and toxic and pretreatment effluent standards established pursuant to Sections 301 302 304 and 307 of the Clean Water Act (CWA) and amendments thereto are applicable to the discharge

14 The action to adopt an NPDES permit is exempt from the provisions of Chapter 3 of the California Environmental Quality Act (CEQA) (Public Resources Code Section 21100 et seq) in accordance with Section 13389 of the California Water Code

15 The Board has notified the Discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for this discharge and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations

16 The Board in a public meeting heard and considered all comments pertaining to the discharge

17 This Order shall serve as an NPDES permit pursuant to Section 402 of the CWA and amendments thereto and shall take effect upon the date of hearing provided USEPA has no objections

IT IS HEREBY ORDERED that the U S Department of Interior Fish and Wildlife Service and the U S Bureau of Reclamation their agents successors and assigns in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder and the provisions of the Clean Water Act and regulations and guidelines adopted thereunder shall comply with the following

A Discharge Prohibitions

1 Discharge of wastewater at a location or in a manner different from that described in Finding No 3 is prohibited

2 The by-pass or overflow of untreated wastewater or wastes into any surface water or surface water drainage course is prohibited except as allowed by the attached Standard Provisions and Reporting Requirements A 13

3 Discharge of toxic or hazardous substances including petroleum products is prohibited

B Effluent Limitations (Discharge 001 and 002)

1 Effluent shall not exceed the following limits

Constituent	Unit	Monthly Average	Daily Maximum
Total Suspended Solids[1]	mg/l	5	15
	lbs/day[2]	300	900
Settleable Solids	ml/l	0 1	0 2
Formaldehyde	mg/l	–	0 03

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[1] Effluent limitations are net values

[2] Based upon 7 2 mgd maximum flow

2 The discharge shall not have a pH of less than 6 5 nor greater than 8 5

3 The maximum daily discharge shall not exceed 7 2 mgd

C Discharge Specifications (Malachite Green Treatment)

1 Water to which malachite green is added shall be treated prior to discharge by passage through GAC canisters The outflow from the canisters shall not exceed the following limit

Constituent	Unit	Average	Maximum
Malachite Green	µg/l	–	10

D Discharge Specifications (Domestic Wastewater)

1 The discharge shall not cause the degradation of any water supply

2 Neither the discharge nor its treatment shall create a nuisance or pollution as defined in Section 13050 of the California Water Code

3 The domestic sewage discharge shall remain underground at all times and there shall be no direct discharge to surface waters or surface water drainage courses

4 Objectionable odors originating at this facility shall not be perceivable beyond the limits of the Discharger s property

E Solid Waste Disposal

1 Collected screening sludges and other solids including fish carcasses shall be disposed of in a manner approved by the Executive Officer

2 Any proposed change in the solid waste disposal practice from a previously approved practice shall be reported to the Executive Officer at least 30 days in advance of the change

F Receiving Water Limitations

Receiving Water Limitations are based upon water quality objectives contained in the Basin Plan As such they are a required part of this Order

The discharge shall not cause the following in the Sacramento River

1 Concentrations of dissolved oxygen to fall below 7 0 mg/l In the event the receiving waters are determined to have a dissolved oxygen concentration of less than 7 0 mg/l the discharge shall not depress the dissolved oxygen concentration below the background level

2 Oils greases waxes or other materials to form a visible film or coating on the water surface or on the stream bottom

3 Oils greases waxes floating material (liquids solids foams and scums) or suspended material to create a nuisance or adversely affect beneficial uses

4 Aesthetically undesirable discoloration

5 Fungi slimes or other objectionable growths

6 Turbidity to increase by more than 1 NTU when the turbidity of the receiving waters is 5 NTU or less or more than 20 percent when the background level is greater than 5 NTU

7 The normal ambient temperature to be altered by more than 5°F

8 Deposition of material that causes nuisance or adversely affects beneficial uses

9 Taste or odor producing substances to impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin or to cause nuisance or adversely affect beneficial uses

10 Radionuclides to be present in concentrations that exceed maximum contaminant levels specified in the California Code of Regulations (CCR) Title 22 that harm human plant animal or aquatic life or that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human plant animal or aquatic life

11 Aquatic communities and populations including vertebrate invertebrate and plant species to be degraded

12 Toxic pollutants to be present in the water column sediments or biota in concentrations that adversely affect beneficial uses that produce detrimental response in human plant animal or aquatic life or that bioaccumulate in aquatic resources at levels which are harmful to human health

13 Violation of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board pursuant to the CWA and regulations adopted thereunder

G Groundwater Limitations

The discharge in combination with other sources shall not cause underlying groundwater to contain waste constituents in concentrations statistically greater than background water quality except for coliform For coliform increases shall not cause the most probable number of total coliform organisms to exceed 2 2/100 ml over any 7-day period

H Provisions

1 The Discharger must comply with all conditions of this Order including timely submittal of technical and monitoring reports as directed by the Executive Officer Violations may result in enforcement action including Regional Board or court orders requiring corrective action or imposing civil monetary liability or in revision or rescission of this Order

2 A copy of this Order shall be kept at the discharge facility for reference by operating personnel Key personnel shall be familiar with its content

3 The Discharger shall use the best practicable cost-effective control technique currently available to limit mineralization to no more than a reasonable increment

4 The Discharger shall comply with all the items of the Standard Provisions and Reporting Requirements for Waste Discharge Requirements (NPDES) dated 1 March 1991 which are part of this Order This attachment and its individual paragraphs are referred to as Standard Provision(s)

5 The Discharger shall comply with the Monitoring and Reporting Program No ______ which is part of this Order and any revisions thereto as ordered by the Executive Officer

When requested by USEPA the Discharger shall complete and submit Discharge Monitoring Reports The submittal date shall be no later than the submittal date specified in the Monitoring and Reporting Program for Discharger Self-Monitoring Reports

6 This Order expires on ___________ and the Discharger must file a Report of Waste Discharge in accordance with Title 23 CCR not later than 180 days in advance of such date in application for renewal of waste discharge requirements if it wishes to continue the discharge

7 Prior to making any change in the discharge point place of use or purpose of use of the wastewater the Discharger shall obtain approval of or clearance from the SWRCB Division of Water Rights

8 In the event of any change in control or ownership of land or waste discharge facilities presently owned or controlled by the Discharger the Discharger shall notify the succeeding owner or operator of the existence of this Order by letter a copy of which shall be immediately forwarded to this office

To assume operation under this Order the succeeding owner or operator must apply in writing to the Executive Officer requesting transfer of the Order The request must contain the requesting entity s full legal name the state of incorporation if a corporation the name address and telephone number of the persons responsible for contact with the Board and a statement The statement shall comply with the signatory paragraph of Standard Provision D 6 and state that the new owner or operator assumes full responsibility for compliance with this Order Failure to submit the request shall be considered a discharge without requirements a violation of the California Water Code Transfer shall be approved or disapproved in writing by the Executive Officer

I GARY M CARLTON Executive Officer do hereby certify the foregoing is a full true and correct copy of an Order adopted by the California Regional Water Quality Control Board Central Valley Region on ______________

GARY M CARLTON Executive Officer

ALM djc 1/20/98

Attachments

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

MONITORING AND REPORTING PROGRAM NO

NPDES NO CA0084298

FOR
U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
AND
U S BUREAU OF RECLAMATION
WINTER RUN REARING FACILITY
SHASTA COUNTY

WATER SUPPLY MONITORING

A sampling station shall be established and located where representative samples of the water supply from above the facility can be obtained Samples shall be collected at approximately the same time as monthly effluent samples Water supply monitoring shall include at least the following

Constituent	Unit	Type of Sample	Sampling Frequency
Total Suspended Matter	mg/l	8 Hr Composite	Monthly[1]
Turbidity	NTU	Grab	Monthly[1]
Dissolved Oxygen	mg/l	Grab	Monthly
Temperature	C	Grab	Monthly
pH	number	Grab	Monthly

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[1] May be reduced to annually during the month of highest feeding if no violations are reported during the first year of sampling

EFFLUENT MONITORING

Discharge 001 and 002

Effluent samples shall be collected immediately downstream from the last connection through which wastes can be admitted into the outfall Effluent samples shall be collected during cleaning of raceways or during administration of chemical treatments and should be representative of the volume and quality of the discharge at that time Time of collection of samples shall be recorded Effluent monitoring shall include the following

Constituent	Unit	Type of Sample	Sampling Frequency
Total Suspended Matter	mg/l lbs/day	8 Hr Composite	Monthly[1]
Turbidity	NTU	Grab	Monthly[1]
Dissolved Oxygen	ml/l	Grab	Monthly
Temperature	C	Grab	Monthly
pH	number	Grab	Monthly
Settleable Matter	ml/l	Grab	Monthly
Flow	mgd	–	Monthly
Formaldehyde	mg/l	Grab	Monthly[2]

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[1] May be reduced to annually during the month of highest feeding if no violations are reported during the first year of sampling

[2] During those months when formaldehyde is being used in waters at the facility which results in formaldehyde becoming a constituent of any discharge

MALACHITE GREEN MONITORING

When malachite green is added to a portion of the hatchery flow and the flow is subsequently treated by passage through the granular activated carbon (GAC) canisters the outflow from the canisters shall be monitored The following shall constitute minimal monitoring and shall be determined by using Waters C_{18} Sep-Pak analysis or comparable method with a detection limit no greater than 10 μg/l

Constituent	Unit	Type of Sample	Sampling Frequency
Malachite Green	μg/l	Grab	Monthly

RECEIVING WATER MONITORING

Receiving waters upstream between and downstream of the discharge points shall be inspected at approximately the same time as the effluent samples are collected A log shall be kept of the receiving water conditions with attention given to the presence or absence of

a Floating or suspended matter
b Discoloration
c Bottom deposits
d Aquatic life
e Visible films sheens or coatings
f Fungi slimes or objectionable growths
g Potential nuisance conditions

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Notes on receiving water conditions shall be summarized in the monitoring report

SEPTIC TANK MONITORING AND INSPECTIONS

Septic tank maintenance inspections (including tank sludge level measurement) shall be performed at least once a year Information concerning inspections and maintenance activities (including but not limited to pumping replacement and repairs) shall be included in the monitoring reports submitted to the Board

LEACHFIELD MONITORING

The Discharger shall inspect leachfield areas weekly and submit the results in the monitoring report. Monitoring shall include any observations of seeps erosion field saturation ponding liquid the presence of nuisance and other field conditions

REPORTING

Monthly monitoring reports shall be submitted to the Regional Board by the 15th day of the month following sample collection A daily log shall be maintained of the quantities of all chemicals used for anesthetic disease control disinfection and all other hatchery operations which result in chemicals becoming constituents of the discharge This information shall be submitted monthly as part of the monitoring report

In reporting the monitoring data the Discharger shall arrange the data in tabular form so that the date the constituents the concentrations and the sampling points are readily discernible The data shall be summarized in such a manner as to clearly illustrate the compliance with waste discharge requirements

If the Discharger monitors any pollutant at the locations designated herein more frequently than is required by this Order he shall include the results of such monitoring in the calculation and reporting of the values required in the discharge monitoring report form Such increased frequency shall be indicated on the discharge monitoring report form

By 31 October each year the Discharger shall submit a written annual report to the Executive Officer containing the following information

a The names and telephone numbers of persons to contact regarding the facility for emergency and routine situations

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b A table showing the quantities (in pounds grams or gallons) of all chemicals used during the previous production year

c The total pounds of fish food used during the previous production year and the pounds of fish produced

The production year shall be defined as the period of time between 1 October and 30 September

The Discharger may also be requested to submit an annual report to the Board with both tabular and graphical summaries of the monitoring data obtained during the previous year Any such request shall be made in writing The report shall discuss the compliance record If violations have occurred the report shall also discuss the corrective actions taken and planned to bring the discharge into full compliance with the waste discharge requirements

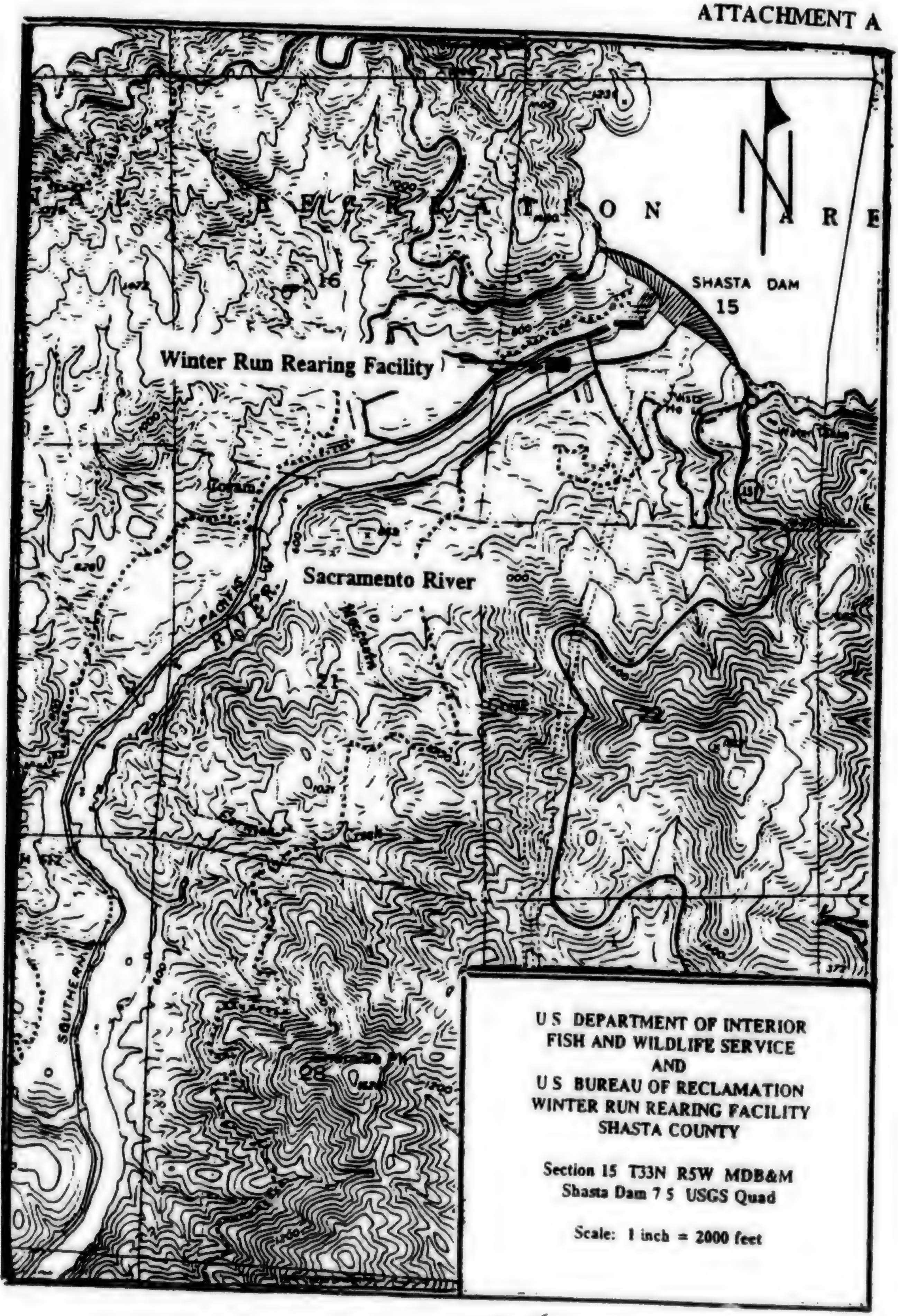
All reports submitted in response to this Order shall comply with signatory requirements of Standard Provision D 6

Ordered by ______________________________
GARY M CARLTON Executive Officer

____
(Date)

ALM djc 1/20/98

ATTACHMENT A

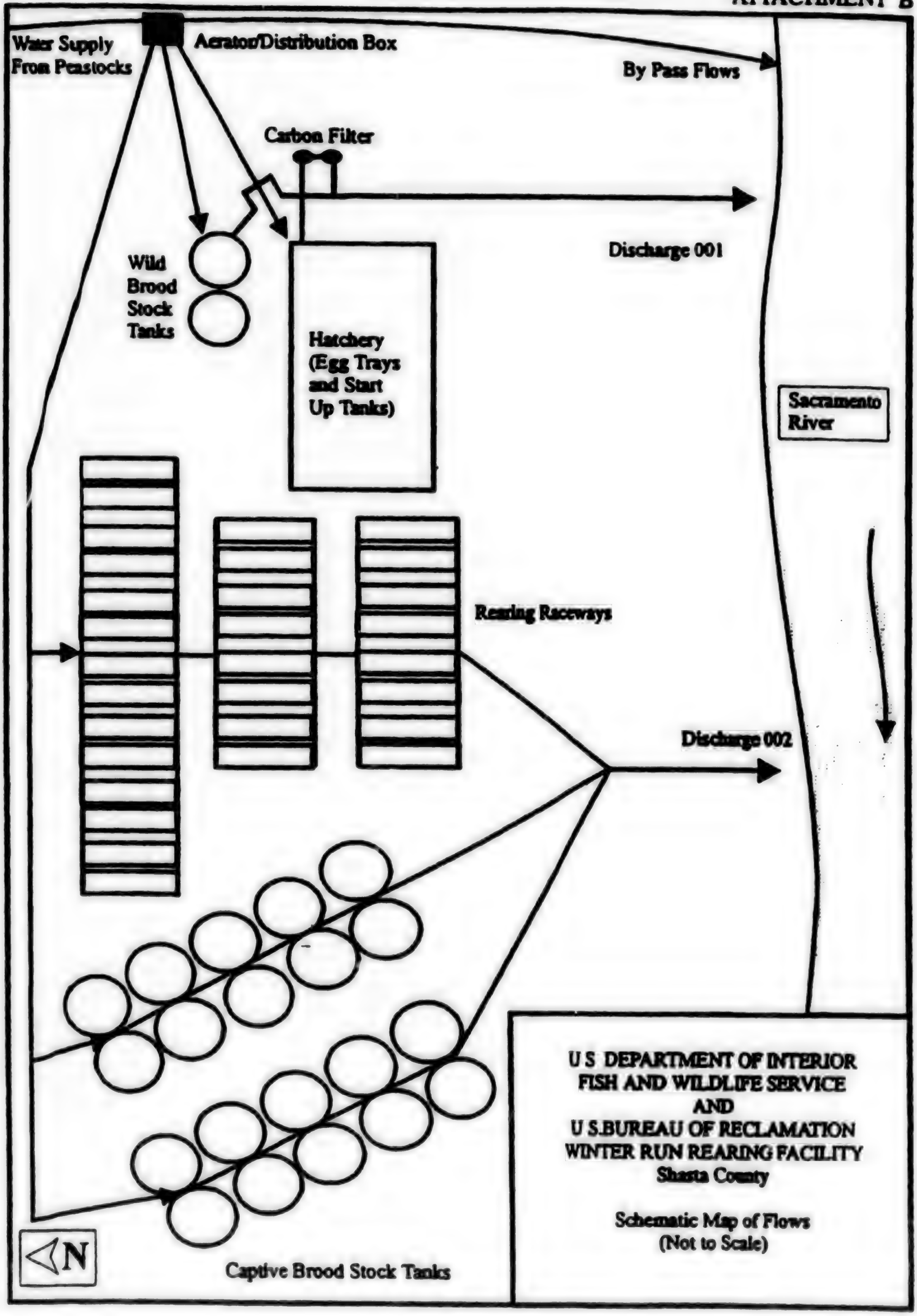


U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
AND
U S BUREAU OF RECLAMATION
WINTER RUN REARING FACILITY
SHASTA COUNTY

Section 15 T33N R5W MDB&M
Shasta Dam 7 5 USGS Quad

Scale: 1 inch = 2000 feet

ATTACHMENT B



U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE
AND
U S.BUREAU OF RECLAMATION
WINTER RUN REARING FACILITY
Shasta County

Schematic Map of Flows
(Not to Scale)

INFORMATION SHEET

U S DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE AND
U S BUREAU OF RECLAMATION
WINTER RUN REARING FACILITY
SHASTA COUNTY

In January 1998 the U S Fish and Wildlife Service proposes to begin operating a winter run chinook salmon rearing facility on land owned by the U S Bureau of Reclamation just downstream of Shasta Dam in Section 15 T33N R5W MDB&M in Shasta County

The new aquaculture facility will divert water from the penstocks of Shasta Dam to rear a yearly average of 16 000 pounds of juvenile and broodstock winter run salmon The water will flow through a variety of circular and rectangular holding tanks before discharging via one of two points into the Sacramento River (Discharge 001 and 002) Maximum feeding is projected to occur in December when approximately 500 pounds will be utilized at the facility

The requirements contain effluent limitations for total suspended solids and settleable matter At this time no settling ponds are proposed for the facility Control of suspended solids and settleable matter in the effluent will be achieved through operational procedures such as the frequency and distribution of tank cleaning

Chemical usage at the hatchery will be primarily a disease preventative measure Chemicals anticipated to be used include malachite green formaldehyde salt oxytetracycline erythromycin, and luteinizing hormone release hormone The requirements contain an effluent limitation of 0 03 mg/l for formaldehyde based on toxicity data from the Department of Health Services Office of Drinking Water and the beneficial uses of the Sacramento River downstream of the discharge Malachite green is a fungicide and parasiticide Its use in fish culture operations in California is prohibited except where the U S Food and Drug Administration grants an Investigational New Animal Drug (INAD) exemption Where an exemption has been granted all water contaminated by malachite green must be treated by passage through granular activated carbon (GAC) canisters prior to discharge into other wastewater flows

The Board has determined that acute toxicity effluent limits are not needed in this permit as this is an aquatic production facility raising larval fish through sensitive critical life stages and can be representative of a continuous bioassay For the same reason three species chronic biotoxicity testing is not being required

Domestic sewage from the facility will be discharged to a septic tank/leachfield system

ALM djc 1/20/98

Attachment 12-1: Intraspecific competition among hatchery-reared and naturally spawned juvenile chinook salmon in the Sacramento River, California.

Intraspecific Competition Among Hatchery-Reared and Naturally Spawned Juvenile Chinook Salmon In The Sacramento River, California

Background and Justification

Hatchery produced salmon are widely used to supplement naturally spawned stocks throughout the west coast of North America where natural stocks have declined in abundance due to habitat degradation blockage of migratory routes over harvest and other factors (Waples 1999) In California s Sacramento River all four seasonal runs of chinook salmon (*Oncorhynchus tshawytscha*) have declined to fractions of their historical numbers (Yoshiyama *et al* 1998) Winter run chinook salmon are state and federally listed as endangered (Federal Register 1994) and the fall late fall and spring runs have been proposed for federal listing as either threatened or endangered (Federal Register 1998) Hatchery fish now compose substantial portions of the fall late fall and winter runs

Construction and operation of the Central Valley Project (CVP) by the U S Bureau of Reclamation (USBR) has impeded anadromous fish migration routes and blocked access to previously available habitat The cooler higher-elevation areas of the Sacramento and McCloud rivers which were particularly utilized by winter run chinook salmon (Federal Register 1994) became inaccessible with the construction of Shasta Dam during the 1940 s (Slater 1963) Major CVP water diversions at Red Bluff (Vogel et al 1988) and Tracy (Liston and Brockman 1999) have also delayed salmon migrations increased susceptibility to predators and increased mortality To mitigate the lost production of naturally reproducing salmonids USBR now funds two U S Fish and Wildlife Service (USFWS) operated hatcheries on the upper Sacramento River system Coleman National Fish Hatchery currently stocks steelhead (*O mykiss*) fall- and late fall run chinook salmon Livingston Stone National Fish Hatchery stocks winter-run chinook salmon exclusively

The use of hatchery programs however has become increasingly controversial due to the potential for negative interactions with natural populations (Incerpi 1996 Waples 1999) Hatchery produced fish now compose large fractions of many runs in California and elsewhere (Federal Register 1998) While hatchery programs are necessary to support commercial recreational and tribal harvest of some populations and to preserve the existence of others (Waples 1999) hatchery fish pose a risk to wild stocks through genetic dilution predation disease transmission competition for spawning areas and competition among juveniles (Yoshiyama *et al* 1998) Throughout this text I use the term wild to mean fish that were produced and reared without human (hatchery) intervention regardless of parental origins Genetic interactions among hatchery and wild salmon have received particular attention (Hindar et al 1991 Waples 1999) however negative impacts on wild stocks through non genetic mechanisms have not been researched as extensively Competition among juvenile hatchery and wild salmon in the Sacramento River has been recognized as a potential detriment to wild stocks (USFWS 1997 Federal Register 1998 Yoshiyama *et al* 1998) largely based on studies involving other salmonid species (e g Bachman 1984 Mesa 1991) and laboratory studies (Berejikian et al 1995 Rhodes and Quinn 1998) To my knowledge no quantitative experiments have been conducted to measure the existence or severity of competition among hatchery and wild chinook salmon in the Sacramento River

Hatchery management strategies affect USBR operations throughout the CVP Congressional passage of the Central Valley Project Improvement Act in 1992 (CVPIA Title 34 of Public Law 102 575) modified USBR s responsibilities for operating the CVP and included provisions to protect restore and enhance fish wildlife and associated habitats in the Central Valley and Trinity River basins of California Specifically CVPIA requires the Secretary of the Department of the Interior to make all reasonable efforts to double average 1967 1991 natural production of anadromous fish in Central Valley streams by the year 2002 (Section 3406(b)(1)) The Secretary directed USFWS and USBR to jointly implement CVPIA, which is being addressed through a series of multi agency actions described in the Anadromous Fish Restoration Plan (AFRP USFWS 1997) A specific action listed in the AFRP is to evaluate and avoid potential competitive displacement of naturally produced juvenile salmonids with hatchery produced juveniles by implementing release strategies for hatchery produced fish designed to minimize detrimental interactions This action cannot be accomplished without further research to quantify and characterize intraspecific competition Furthermore any management strategies that are counter-productive to increasing wild populations in the Sacramento River will likely affect CVP operations through additional listings and critical habitat designations under the Endangered Species Act (Federal Register 1998)

This study will evaluate the existence and relative intensity of competition among hatchery-reared and naturally produced juvenile chinook salmon under currently employed release conditions If significant competition is occurring this study will assist managers in selecting future hatchery release strategies (release numbers size classes and timing) to minimize competitive displacement of wild fish

Previous Work and Present Outlook

Competition occurs when multiple organisms exploit a common resource and the fitness of at least one of the organisms is negatively affected either because the resource is in short supply or other organisms interfere with utilization (Birch 1957) Competition may be demonstrated by showing a reduction in one or more measures of fitness such as growth fecundity or survival when multiple organisms are in sympatry as compared to allopatry (Crowder 1990) In general conspecifics share the same resource requirements and therefore are likely to compete when population densities are great enough to exhaust the resources that are least abundant in relation to demand i e limiting resources

Because most fish species are highly fecund high densities of newly emerged juveniles can exhaust limiting resources contributing to a critical period of exceptionally high mortality during the first day to year of life (Wootten 1990) Humans have typically intervened to improve salmonid recruitment by using hatcheries to provide otherwise limiting resources during the critical period Early life density dependent mortality can exert selective pressure on fish populations for faster growing fish better predators or individuals that are otherwise more fit Conversely hatchery propagation can alter population structures by introducing fish that otherwise would not have survived the critical period but later compete or interbreed with wild fish (Hindar 1991)

Other means of providing resources under more natural conditions which would presumably minimize differences between hatchery and wild fish have been explored but not widely implemented to date These include natural rearing hatchery management strategies (Maynard et al 1996) and supplementing food in recently stocked streams to decrease density dependent mortality (Mason 1976 Irvine and Bailey 1992)

Stream dwelling salmonids generally compete for advantageous stream positions that confer food refuge cover or other resources (Chapman 1966 Fausch and White 1981 Bachman 1984) Low water velocity positions adjacent to areas of higher velocity are preferred because they provide energetically favorable areas to hold station near efficient (high drift) food sources (Fausch and White 1981 Bachman 1984 Fausch 1984) Individuals occupying more favorable stream positions grow faster (Li and Brocksen 1977 Fausch 1984) and thus increase their chance of survival (Quinn and Peterson 1996 Holtby *et al* 1990) Local assemblages may form dominance hierarchies with dominant fish monopolizing access to preferred positions (Chapman 1962 Bachman 1984) Where high densities of juveniles compete for advantageous positions increased downstream displacement and mortality have been documented in several salmonid species (Hearn 1987) Dominance appears positively related to size (Noakes 1980 Swain and Riddell 1990, Berejikian et al 1996) but may also be related to previous agonistic experience recognition aggression and prior residence (Rhodes and Quinn 1998)

Hatchery produced salmonids have strong potential to displace wild fish because they tend to be more aggressive than their wild counterparts (Fenderson *et al* 1968 Swain and Riddell 1990 Mesa 1991) Additionally salmon of hatchery origin often have a size advantage due to prior feeding regime or genetics (Nickelson *et al* 1986 Rhodes and Quinn 1999) Although salmonids of hatchery origin may be less fit than wild fish because they expend energy unnecessarily (Bachman 1984 Mesa 1991) feed less (Fenderson *et al* 1968) and exhibit lower predator avoidance ability (Olla et al 1994) hatchery fish may negatively impact wild fish through interference and over-aggressive defense of territories Based on a live stream study Mesa (1991) speculated hatchery reared cutthroat trout have not learned to balance the cost of aggressive behavior with the benefits gained by aggression because high densities in hatcheries preclude the development of dominance hierarchies Nickelson et al (1986) observed juvenile wild coho salmon densities were 44% lower in Oregon streams supplemented with hatchery coho than in unstocked streams They concluded that hatchery juveniles displaced wild juvenile fish resulting in no net increase in the adult populations of supplemented streams

Both genetic background and rearing environment may influence differential behavior among hatchery reared and wild salmonids Rhodes and Quinn examined the effect of hatchery rearing on coho salmon of similar genetic backgrounds in two studies Under laboratory conditions Rhodes and Quinn (1998) demonstrated hatchery reared coho salmon overcame prior residence experience and dominated wild fish of the same size They attributed the difference to lack of prior losing experience for hatchery reared salmon However Rhodes and Quinn (1999) found no significant differences between survival or emigration rates of hatchery and wild coho salmon in two streams despite a mean initial size advantage of 10% for hatchery fish and higher hatchery fish growth rates (adjusted for size)

Domestication over many generations may also create genetic differences that are responsible for differential hatchery/wild fish behavior Berejikian et al (1996) found wild steelhead exhibited higher mirror-elicited agonistic behavior than hatchery reared steelhead and were dominant in direct challenges However steelhead of hatchery stock that were raised in natural environments became more aggressive than wild fish suggesting genetic differences were responsible for greater aggression in hatchery fish when corrected for rearing environment Hatchery fish also generally won dominance challenges at relatively small (3 4 5%) size advantages In a laboratory experiment Swain and Riddell (1989) also found coho salmon of hatchery stock were genetically predisposed greater mirror elicited agonistic behavior than wild fish reared under identical conditions

Richards and Cernera (1989) found hatchery stocked chinook salmon in an Idaho stream did not disperse to take advantage of available habitat despite local densities that were thought to be near carrying capacity This low dispersion would exacerbate any competitive interactions that might be occurring between hatchery-reared and wild salmon Symons (1969) also observed lower dispersion of hatchery reared Atlantic salmon than their wild counterparts He speculated previous mark recapture studies that estimated relatively high hatchery reared salmon survival were biased due to the higher emigration rate of wild fish

On the Sacramento River hatchery release strategies are designed to minimize freshwater interactions between hatchery and naturally produced fish nevertheless the impact of hatchery releases on naturally produced fish has not been quantified and remains contentious Hatchery fish are generally released in en masse at times of the year when physiological and environmental conditions promote rapid outmigration – that is hatchery fish have begun to exhibit signs of smolting and river discharge/turbidity is high (Scott Hamelburg USFWS personal communication) The underlying assumption is that hatchery fish actively migrate to the delta within several days minimizing the interaction period with in river fish and thus the ecological risk However an unknown fraction of hatchery fish delays outmigration and potentially competes with naturally produced salmon Hatchery fish marked with adipose fin clips have been captured in rotary screw traps at Red Bluff Diversion Dam several weeks after release (Craig Martin USFWS personal communication)

If competition among hatchery and wild fish in the Sacramento River exists it is likely to occur through two mechanisms (1) The large initial pulse of hatchery fish through the river system locally inundates carrying capacity and displaces wild fish as it passes In this case displaced fish might be forced into the delta at smaller sizes or less physiologically prepared states (chinook salmon rarely emigrate upstream Richards and Cernera 1989) (2) Hatchery fish that delay outmigration compete with wild fish over a longer period of time thereby reducing growth rates or increasing mortality

Goals and Objectives

The overall goal of this study will be to evaluate the existence and relative intensity of competition among hatchery reared and naturally spawned fall run chinook salmon in the Sacramento River

Specific objectives will be

(1) Determine patterns of hatchery fish outmigration Observe timing of peak outmigration and relative number of delayed outmigrants at various locations on the Sacramento River This will be an observational study used to determine appropriate densities for competition experiments

(2) A Determine if hatchery fish displace wild fish at densities and under conditions similar to those occurring in the Sacramento River when fall run chinook salmon are released from Coleman National Fish Hatchery

Hypotheses

H_0 Wild fish migrations are unaffected by hatchery fish downstream movement

H_A Wild fish are more likely to emigrate downstream as high densities of hatchery fish move through a given area

B If wild fish are being displaced determine how their physiological status compares with other wild fish that migrate in the absence of hatchery fish

Hypotheses

H_0 Displaced fish exhibit similar physiological characteristics to wild fish that migrate in the absence of hatchery fish

H_A Displaced fish exhibit lower condition factors growth rates or other physiological characteristics than wild fish that migrate in the absence of hatchery fish

(3) A Determine the existence of competition among hatchery fish that delay outmigration and wild fish at densities and under conditions similar to those occurring in the Sacramento River following peak outmigration of hatchery fish

Hypotheses

H_0 Wild fish growth and mortality are unaffected by the presence of hatchery fish that delay outmigration at densities typically occurring in the Sacramento River

H_A Wild fish growth is reduced or mortality is increased by the presence of hatchery fish that delay outmigration

B If competition among wild and delayed outmigrant hatchery fish exists determine if it is attributable to unique characteristics of hatchery fish or is a function of density

Hypotheses

H_0 Competition among hatchery and wild fish is no greater than competition among wild fish at the same total density

H_A Competition among hatchery and wild fish is greater than competition among wild fish at the same total density

Methods

Hatchery Fish Outmigration

Relative abundance of hatchery and wild salmon will be estimated at fixed transects on the Sacramento River just prior to and for several weeks following fall run chinook salmon releases in mid April These data will be collected using standard beach seines in predetermined areas to obtain catch per unit effort estimates (catch per m^2 seined) A known fraction (normally about 10%) of fish from each hatchery release will be identifiable by the presence of clipped adipose fins Total number of hatchery fish captured will be estimated by extrapolation of the number of adipose fin clip captures to total number of captures in the same length class Sampling methods will be similar to but more formalized than those currently employed by the USFWS Captured fish will be anesthetized in MS 222 enumerated and measured to the nearest mm All captured fish will be released into the same area following recovery Pilot data for this study may be obtained from the USFWS

Seining data will be used to estimate the pattern and timing of hatchery fish outmigration Specifically these data will be used to estimate the fraction of hatchery fish that actively migrate to the delta within several days after release and the locations and residence times of those that residualize In order to approximate real world conditions as closely as possible relative numbers of hatchery and wild fish will also be used to calibrate the number of fish used in competition experiments following the first year of data collection Seining data may also provide additional empirical support for displacement experiments

Displacement Experiment

Displacement of wild fish by hatchery fish will be tested using enclosure experiments near seining sites Approximate 10 x 5 m enclosures constructed of heavy conduit and hardware wire will be set in the river margin during mid-April when fall run hatchery fish are being released Enclosures will have funnel type traps attached to the downstream ends allowing emigration to separate live boxes Naïve wild fish of known sizes and number will be obtained by beach seine added to enclosures and allowed to acclimate for several days prior to beginning experiments

Paired treatment and control enclosures will be used in this experiment (Figure 1) Adipose fin clipped hatchery fish will be added to treatment enclosures at numbers similar to their relative abundance in seine transects at the particular location along the stream gradient Control enclosures will contain wild fish only All fish caught in downstream live boxes will be removed from enclosures

Wild salmon caught in downstream boxes will be enumerated weighed and measured Relative preparation for smolting may be sampled using skin reflectance (Haner et al 1995) body morphology (Beeman et al 1993) Gill (Na^+ K) ATP ase (Schrock et al 1994) or some other appropriate method Enclosures will be monitored until >90% of the hatchery fish have emigrated from the treatment enclosure Remaining fish will then be captured from the enclosures Captured fish will be weighed measured enumerated and released back into the river Treatment and control groups of wild salmon caught in downstream traps will be compared for differences in mean size condition and preparation for emigration and smolting Although necessary sample size will be determined by power analyses following one year of pilot data collection initial sampling will be conducted using eight replicate enclosures containing 33 wild fish and up to 50 hatchery fish

Delayed Outmigrant Competition Experiment

Competition among wild and hatchery fish will be tested using enclosures similar to those described above except that no fish will be allowed to emigrate These experiments will begin in mid to late April following displacement experiments Experimental fish will be weighed measured and added to enclosures according to Figure 1 Naïve wild fish will be obtained by beach seine from other river sections Hatchery fish will be obtained directly from Coleman National Fish Hatchery No fish will be permitted to immigrate or emigrate from the enclosures after the experiment has begun The experiment will be conducted for a period of weeks equal to the mean residence time of delayed outmigrant hatchery fish as determined by seining observations described above Densities of experimental fish will also be empirically determined from beach seine data after the pilot year of data collection

Since the objectives of this experiment are to test both the existence and extent of competition among wild and hatchery fish three treatments will be used (Figure 1) Although differences may exist between hatchery and wild fish, the null hypothesis is that increasing fish density will have an equal effect on fitness regardless of the origin of added fish Therefore the effect of density must be quantified to test for a hatchery fish effect (Fausch 1998 *sensu*)

At the conclusion of the experiment all fish will be removed enumerated weighed and measured Missing fish will be assumed deceased Size and mean growth of remaining fish will be compared among treatments

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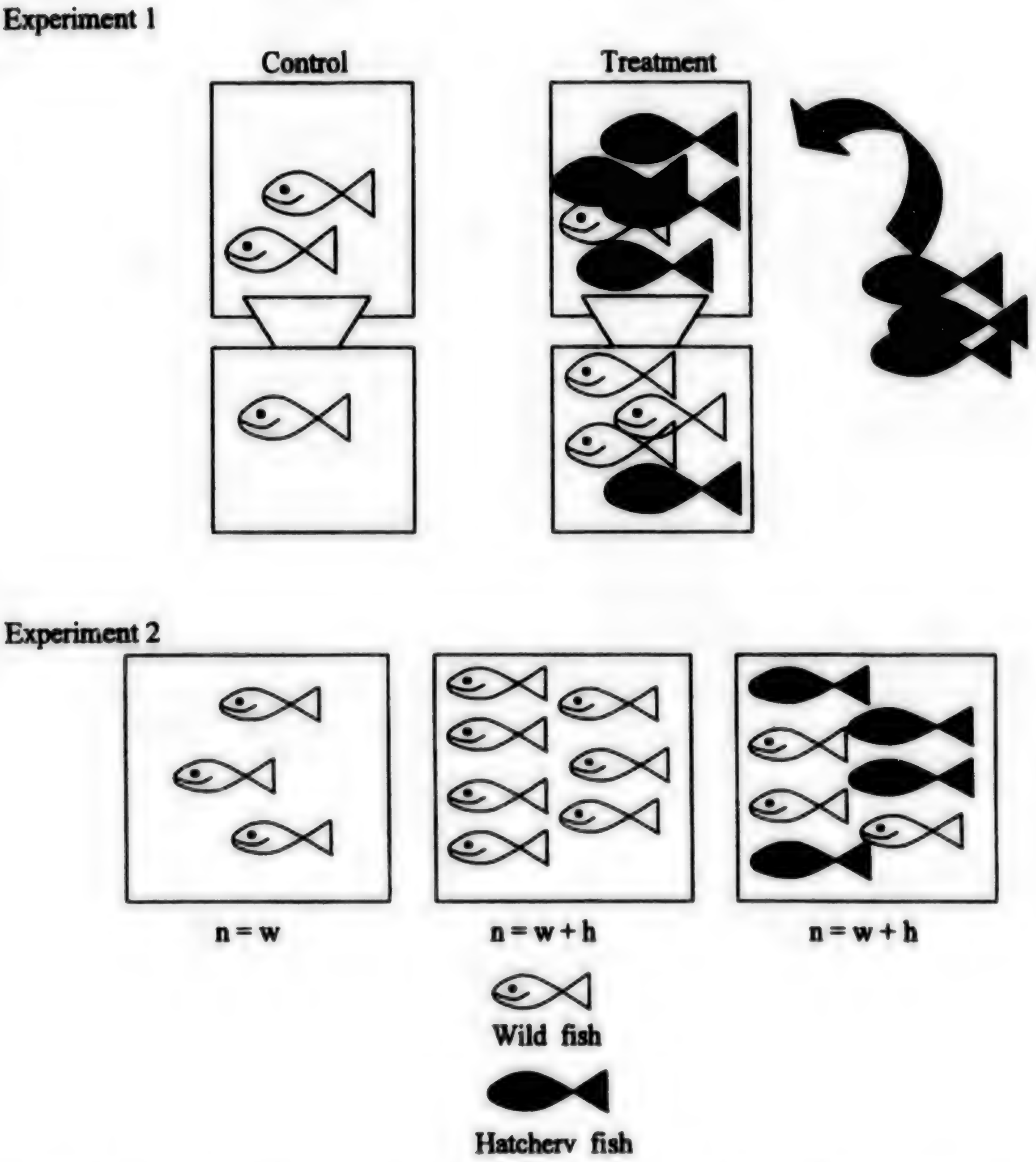

Figure 1 Schematic of hatchery/wild salmon enclosure experiments Experiment 1 — hatchery fish will be added to treatment enclosures Emigration rates and physical characteristics of wild fish will be compared between treatment and control Experiment 2 — three treatments will be used to examine growth and survival of wild fish at low and high densities and wild versus hatchery fish at high densities The letter n indicates number of fish per enclosure w indicates number of wild fish needed to simulate typical in river densities and h the number of hatchery fish Actual numbers (w and h) will be based on beach seining data

Attachment 12 2 Progress Report Intraspecific competition among hatchery reared and naturally spawned juvenile chinook salmon in the Sacramento River California

Progress Report

Intraspecific Competition among Hatchery Reared and Naturally Spawned Juvenile Chinook Salmon in the Sacramento River, California

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Prepared for
U S Bureau of Reclamation
Fisheries Applications Research Group
Technical Service Center
Denver CO 80225-0007

Cooperative Agreement 00 FC 81 0202
Research for Mitigation for Lost Production of Naturally Reproducing Salmonids in the Sacramento River

June 2000

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Summary – We collected our first year of data on the Sacramento River between 7 April and 29 May 2000 to evaluate hatchery chinook salmon *Oncorhynchus tshawytscha* outmigration patterns the extent to which naturally spawned chinook salmon were displaced by hatchery fish and the effects of high densities of hatchery reared juveniles on naturally spawned salmon We monitored outmigration patterns by periodically enclosing a 6 1 x 30 5 m (20 x 100 ft) area of the river and obtaining density estimates using beach seine depletions Potential displacement was evaluated by adding hatchery reared fish to 8 m^2 enclosures containing natural densities of wild fish then measuring voluntary emigration through traps at the downstream end of each enclosure We also used the 8 m^2 enclosures to evaluate the effects of forced sympatry between hatchery-reared fish and their naturally spawned counterparts no fish were permitted to emigrate from these enclosures In general these techniques proved suitable for answering the research questions outlined in the project proposal Enclosures withstood relatively high river discharge and debris loads without damage We are currently analyzing these data to be included in the project annual report and refining the study design for future years

Hatchery fish outmigration – Fourteen depletions of a rectangular 6 1 x 30 5 m (20 x 100 ft) area at the margin of river were conducted between 14 April and 22 May to estimate juvenile salmon density and timing of hatchery fish outmigration We sampled an area offshore of Altube Island just below the Red Bluff Diversion Dam at river kilometer 391 (river mile 243) The area was delineated using metal posts set in a rectangular pattern with the shoreline constituting one of the long sides Nylon netting (0 64 cm [1/4 in] mesh size 1 8 m [6 ft] height) was then attached to the posts around the perimeter of the area To allow fish to return to the area after disturbing it the bottom of the net was raised along approximately 50% of its length for a minimum of one hour We then quickly closed the openings and conducted 3 to 7 depletion passes inside the area using a beach seine The area was measured during each sample to account for water level fluctuation that changed shoreline position A velocity and depth profile of the area was measured on 16 May

We were unable to obtain pre release estimates of naturally spawned chinook salmon abundance because approximately 500 000 hatchery reared juveniles were released from Coleman National Fish Hatchery (CNFH) on 7 April prior to scheduled releases Hatchery releases had been scheduled for 14 April and 21 April but the outbreak of a bacterial infection prompted CNFH to release fish earlier We attempted to obtain a density estimate on 7 April before released fish could reach Red Bluff However we employed a different net configuration than that described above and the method proved unsuccessful

We also attempted to characterize densities of naturally spawned juvenile salmon by sampling the Sacramento River well upstream of CNFH in Redding CA Bed topography and depth of the area did not allow for the same configuration used in Red Bluff Instead a 6 1 x 15 2 m (20 x 50 ft) parallelogram was sampled on 19 April Subsequent seining in the area to obtain fish for use in enclosure experiments revealed that fish densities were highly variable Therefore the original project objective of selecting a single density for use in enclosure experiments based on this type of sampling may be inappropriate A better goal is to select a density near the upper end of those reported for juvenile chinook salmon based on previous sampling in the Sacramento River and elsewhere to simulate the effects of hatchery releases on high densities of wild fish

A total of 385 fall run and 19 late fall run chinook salmon were captured in this portion of the study Run membership was designated based on fork length and date of capture according to data provided by The California Department of Fish and Game Three steelhead/rainbow trout *O mykiss* fry were also incidentally captured Late fall and very small fall run salmon (<46 mm) numbers may have been underestimated because the 0 64 cm mesh probably was not fully efficient at holding them inside the sampled area. A total of 10 fish captured between 17 April and 16 May had clipped adipose fins which confirmed their hatchery origin An 8% sample of fall run hatchery salmon was adipose fin clipped by CNFH prior to release Relatively large numbers of juvenile salmon were captured on 17 April to 19 April and 22 and 23 April within several days after hatchery releases Large numbers were also captured on 16 May the day after Red Bluff Diversion Dam gates were lowered

Displacement experiment – This experiment was conducted to test the hypothesis that high densities of hatchery fish moving downstream prompt wild fish to emigrate prematurely We performed the experiment using six enclosures (three treatment and three control randomly selected) constructed of heavy Durathene® plastic mesh with 0 64 cm (1/4 in) openings attached by aluminum wire to frames constructed of 2 54 cm (1 in) diameter polyvinyl chloride (PVC) tubing Enclosure dimensions were 2 m x 4 m x 1m high with an additional 0 5 x 2 m trap on the downstream end of each enclosure The downstream trap was separated from the main enclosure by a funnel which allowed fish to emigrate but discouraged movement back to the main enclosure We placed enclosures along the river margin near Altube Island just upstream from the site of the outmigration study The bottom of each enclosure was filled with 5 to 16 cm (2 to 6 in) of riverbed gravel typically 2 5 to 8 cm (1 to 3 in) in diameter

Wild fall run chinook salmon were captured using a beach seine in the Sacramento River at Redding CA and held in the Red Bluff Research Pumping Plant river water facility for up to 72 h prior to the experiment Hatchery-reared fish were obtained from CNFH and maintained in the same laboratory All fish were weighed and measured before the experiment Within each enclosure fish were assigned unique marks based on a system of four colors of acrylic paint that was injected subcutaneously into one or more of four areas of the body (caudal fin dorsal fin anal fin or lower jaw) To insure that fish injured by marking and handling were not used in the experiment all fish were held overnight and replaced if they died or did not appear to be swimming normally by the following morning

Forty wild fish (5 per m^2) averaging 52 mm (fork length) were added to each enclosure and allowed to acclimate for 4 h on 1 May No wild fish emigrated from the enclosures to the downstream traps during the acclimation period Thirty three hatchery reared fish averaging 77 mm were then added to the three treatment enclosures Based on a review of the literature these densities were near carrying capacity for salmonids of these sizes (Grant and Kramer 1990 Fausch 1993) Therefore the experiment simulated an area that was already occupied to carrying capacity by wild salmon which was then inundated with hatchery reared fish as might occur after a hatchery release The downstream traps were checked one or two times per day until 9 May Fish captured in the traps were removed weighed and measured The experiment was ended on May by removing gravel and capturing fish remaining in the enclosures Remaining fish were weighed and measured to evaluate growth and condition

Wild fish emigrated from each of the three treatment enclosures (5 to 17 fish) and from two of the three control enclosures (10 and 12 fish) Eleven to twenty-six hatchery fish emigrated from treatment enclosures All hatchery fish and 90 100% of the wild fish were recovered Missing fish were presumed to be dead We are currently conducting a detailed analysis of these data

Competition experiment – This experiment was conducted to test the effects of forced sympatry between hatchery fish and wild fish This would occur if significant numbers of hatchery fish delayed outmigration or if wild fish were displaced downstream as hatchery fish were outmigrating The experiment was conducted using the six enclosures employed in the displacement experiment and three additional enclosures which were constructed while the displacement experiment was taking place For this study the downstream traps were blocked forcing all fish to remain inside Enclosures were placed in the river and substrate was added as described above

Hatchery and wild juvenile salmon were captured held and individually marked with acrylic paint similarly to the displacement experiment The length and weight of each fish was measured prior to the experiment as before To differentiate the effect of increased densities from the unique effect of hatchery fish three treatments were employed 1 low density wild fish enclosures contained 40 wild fish (5 per m^2) 2 wild fish plus hatchery fish enclosures contained 40 wild fish plus 33 hatchery fish and 3 high density wild fish enclosures contained 73 wild fish (40 plus an additional 33) Each treatment was replicated in three enclosures chosen at random

Fish were added to enclosures on 15 May Enclosures were snorkeled inside and out on 16 May to ensure that no holes were present that would allow escape We found three dead fish in enclosures on 16 May and replaced them Thereafter enclosures were checked daily using a view bucket to account for as many dead fish as possible before they decomposed No dead fish were replaced after 16 May The experiment was run for two weeks and ended on 29 May Fish were removed from enclosures and counted as described above for the displacement experiment All remaining fish were weighed and measured the following day Missing fish were presumed to have died and decomposed

We recorded water velocity and depth profiles inside and directly in front of enclosures on 28 May These data may be used as covariates to explain fish growth and condition within individual enclosures

Mortality rates were highest for hatchery fish averaging 42% (33 to 55 %) and lowest for wild fish in enclosures that contained hatchery fish and wild fish (mean 9%) Wild fish in high density enclosures had slightly higher mortality rates (mean 21%) than wild in low density enclosures (15%) Conclusions about this experiment also await detailed analysis of the data

Problems and sources of error – The construction of enclosures required more time than anticipated which affected all three portions of the project The time required to construct enclosures prevented our replicating the hatchery fish outmigrant sampling at more than one site We could not have completed enough enclosures to run the two experiments near the dates of hatchery releases had we allocated more effort to the outmigrant study during April The slower than expected construction of enclosures also forced us to use fewer replicates for both experiments than we anticipated (three for each treatment and three control) Moreover the competition experiment did not begin until 5/15/00 one month after the first hatchery release By this time experimental hatchery fish began to appear silvery and exhibited high sensitivity to handling and marking These symptoms suggest that hatchery-reared fish were undergoing transformation from parr to smolt which may have biased our experiments We will begin work earlier in spring 2001 to avoid these problems and preempt any unplanned hatchery releases

The considerable water level fluctuation caused by storm events and changes in discharge from Shasta Dam resulted in high variability in flow and current patterns around enclosures during the study This probably influenced the amount of invertebrate drift into enclosures and therefore the quality of the habitat Mean daily discharge at the U S Geological Survey Bend Bridge gauging station near the study area varied during the study from 273 to 422 m^3 (9 624 to 14 899 cfs) resulting in stage differences greater than 0 6 m (2 ft) Had we started experiments earlier in April the difference would have been even greater For example the river reached 498 m^3 (17 585 cfs) following a storm event on 18 April Because enclosures are not quickly moveable after gravel is added we will design the tops of enclosures to be fish-tight for the remainder of the study thereby allowing experiments to continue if enclosures are completely submerged for brief periods A second modification will be to orient enclosures with the long sides perpendicular to the current This will allow fish to better seek desired depths and water velocities as water levels fluctuate The spacing and placement of enclosures may be altered in future years to insure that drift and flow characteristics are similar among replicates A positive aspect of the study was that surviving fish grew relatively quickly in the enclosures during both the displacement and competition experiments In many such experiments reported in the literature all fish lost weight

We observed that a few fish that died had infections around acrylic dye marks We will use finer needles and attempt to improve our technique when marking fish or find an alternate method of creating individual marks

Future plans – We are currently analyzing the spring 2000 data The remaining effort for this year will be to complete this detailed analysis of survival and growth document this study in the project annual report and refine the study design for 2001 based on these data

Interagency cooperation – We thank Max Stodolski Sandy Borthwick and Richard Corwin of the U S Bureau of Reclamation for allowing us to use the laboratory facilities at Red Bluff Research Pumping Plant and providing on site advice and assistance Scott Hamelberg Craig Martin and William McKinney of the U S Fish and Wildlife Service provided background and advice and loaned us several seines Coleman National Fish Hatchery provided approximately 1 000 juvenile salmon for use in this study Daniel Free of the National Marine Fisheries Service and Katherine Perry of the California Department of Game and Fish assisted with state and federal permitting

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Attachment 12 3 Research Proposal Sacramento River winter chinook salmon carcass survey 2001 through 2003

Proposal # 2001-__ ______________(Office Use Only)

A. COVER SHEET

Proposal Title: **Sacramento River Winter Chinook Salmon Carcass Survey**
Applicant Name: **Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office**

Primary Contact: **James G. Smith**
Mailing Address: **10950 Tyler Road**
Red Bluff, CA 96080
Telephone: **(530) 527-3043**
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Amount of funding requested: **$93,765 (Year 1), $103,449 (Year 2), $108,059 (Year 3)**

State cost: $__________________ Federal cost: $__________________

Cost share partners? ____Yes ____No **XXX** (Identify partners and amount contributed by each)

Indicate the Topic for which you are applying (check only one box).

Natural Flow Regimes
Nonnative Invasive Species
Channel Dynamics/Sediment Transport
Flood Management
Shallow Water Tidal/ Marsh Habitat
Contaminants
Beyond the Riparian Corridor
Local Watershed Stewardship
Environmental Education
Special Status Species Surveys & Studies
■ **Fishery Monitoring, Assessment & Research**
Fish Screens

What county or counties is the project located in? **Shasta County**

What CALFED ecozone is the project located in? **3.1 Sacramento River**

Indicate the type of applicant (check only one box):

State agency
Public/Non-profit joint venture
Local government/district
University
Other:
■ **Federal agency**
Non-profit
Tribes
Private party

Indicate the primary species which the proposal addresses (check all that apply):

San Joaquin and East-side Delta tributaries fall-run chinook salmon
■ **Winter-run chinook salmon**
Late-fall run chinook salmon
Delta smelt
Splittail
Green sturgeon
White Sturgeon
Waterfowl and shorebirds
Migratory birds
Other listed T/E species:
Spring-run chinook salmon
Fall-run chinook salmon
Longfin smelt
Steelhead trout
Striped bass
All chinook species
All anadromous salmonids
American shad

Indicate the type of project (check only one box)

■ **Research/Monitoring**
Pilot/Demo Project
Full scale Implementation
Watershed Planning
Education

Is this a next phase of an ongoing project? Yes XXX No____

Have you received funding from CALFED before? Yes No XXXX____

If yes list project title and CALFED number

Have you received funding from CVPIA before? Yes XXX No____

If yes list CVPIA program providing funding, project title and CVPIA number (if applicable) XXXX

The U S Fish and Wildlife Service has previously received funding for this project through an AFRP proposal entitled *Expanded winter-run chinook salmon carcass survey Upper mainstem Sacramento River* The Department of Fish and Game has also received previous funding for this project through AFRP and CVPIA The title of CDFG s AFRP proposal is *Winter-run chinook salmon escapement survey Sacramento River* Additional funding for CDFG was secured through CVPIA/AFRP as part of the AFRP project entitled *Continue to conduct instream flow studies on the Sacramento American and Merced rivers*

By signing below the applicant declares the following

The truthfulness of all representations in their proposal

The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization) and

The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2 4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant to the extent as provided in the Section

Printed name of applicant James G. Smith

Signature of applicant

B. EXECUTIVE SUMMARY.

Proposal Title: Sacramento River Winter Chinook Salmon Carcass Survey

Applicant Name: Fish and Wildlife Service
Northern Central Valley Fish and Wildlife Office

Primary Contact: James G. Smith
Mailing Address: 10950 Tyler Road
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Amount of funding requested: **$93,765 (Year 1), $103,449 (Year 2), $108,059 (Year 3)**

Participants and collaborators: California Department of Fish and Game
Environmental Services Division
Stream Flow & Habitat Evaluation Program
Sacramento, CA

1. Project Description And Primary Objectives:

The Sacramento River winter chinook salmon carcass survey takes place in Shasta County, from Keswick Dam at river mile (RM) 301 downstream to powerline below Clear Creek Riffle (RM 292). This area, included in CALFED Ecozone 3.1 (Sacramento River, Keswick Dam to Red Bluff Diversion Dam), contains the majority of available spawning habitat for state and federally listed endangered winter chinook salmon.

The U.S. Fish and Wildlife Service's Northern Central Valley Fish and Wildlife Office and California Department of Fish Game's Stream Flow and Habitat Evaluation Program will continue to jointly conduct a spawning ground carcass survey to estimate escapement of winter-run chinook salmon. This project as proposed is a monitoring program designed to estimate the abundance of adult endangered winter-run chinook salmon with greater accuracy than estimates generated through the Red Bluff Diversion Dam fish ladder counts. Other objectives will be: to collect baseline information on several important life history attributes of winter chinook salmon (i.e. age, sex ratio, temporal and spatial spawning distribution, and pre-spawning mortality); to evaluate the effectiveness of the winter chinook salmon propagation program to assist in species recovery; and, to collect tissue for genetic analysis to characterize winter-run chinook salmon population (for run discrimination work and to maintain genetic diversity in hatchery and natural stocks).

Of primary importance, the monitoring program tests the hypothesis that current and future implementation of AFRP, CVPIA, CALFED or other restoration program action and activities are resulting in a measurable and scientifically defensible increase in abundance of this endangered species. This monitoring action is therefore in direct support of CALFED ERP Goal 1 (Recovery of At-Risk species) as presented in the PSP.

C. PROJECT DESCRIPTION.

1. Statement of the Problem

a. Problem

Accurate estimation of the number of endangered winter-run chinook salmon that return to the upper Sacramento River is critical to provide a direct measure of the success of AFRP and other management activities intended to directly increase population numbers of salmon and steelhead. Estimation of winter-run chinook salmon run-size using Red Bluff Diversion Dam (RBDD) counts through the ladders accounts for the final 15% of the run Winter-run chinook salmon. Mainstem carcass surveys, however, executed during May though August have distinct advantages over the Red Bluff Diversion Dam (RBDD) estimation method, in that the entire spawning period is encompassed. The collection of information to allow more accurate estimations of population size and structure, will provide the basis for identifying future management actions necessary to accomplish AFRP goals and listed species recovery and delisting.

Primary objectives of the winter chinook salmon mainstem carcass surveys are three fold: 1) to estimate escapement of winter chinook salmon; 2) to evaluate the potential for hatchery supplementation to assist in species recovery; and, 3) to collect tissue samples for genetic analysis to characterize winter-run chinook salmon population (for run discrimination work and to maintain genetic diversity in hatchery and natural stocks). In addition to collecting data on spawner abundance, information is also collected during the field surveys regarding several important life history attributes of winter chinook salmon including age and sex composition, pre-spawning mortality, and temporal and spatial distribution of spawning.

Winter chinook salmon spawn exclusively in the upper Sacramento River the upper reaches of tributaries to the upper Sacramento River. Since 1971, escapement estimates for winter chinook salmon have been based upon counts of salmon passing through fish ladders at Red Bluff Diversion Dam (RBDD; river mile 243). Between 1971 and 1986, RBDD was typically operated throughout the entire period of winter chinook salmon migration in the upper Sacramento River (December - July) allowing for complete accounting of escapement. Beginning in 1987, operation of RBDD was restricted to facilitate improved passage of winter chinook salmon which were at critically low and declining population levels and had been previously petitioned for listing (October 1985) under state and federal Endangered Species Act (ESA). Since 1995, the RBDD has been operated from approximately 15 May through 15 September.

Current winter chinook salmon population estimates based on RBDD fish counts are calculated by expanding weekly fish passage estimates based on the average proportion of passage recorded during historic, season-long counts. Based upon complete season counts made prior to 1987, an average of only about 15% (range: 4.7-24.3%) of the winter chinook salmon spawner population pass RBDD after 15 May (Snider et al. 1997). With the majority (average approx. 85%) of winter chinook migration occurring outside the season of RBDD operation, the accuracy of spawner estimates based on fish ladder counts are, therefore, highly suspect. The winter chinook salmon spawning ground survey ("carcass survey") has been conducted since 1996 to augment RBDD escapement estimates (Snider et al. 1997, 1998, 1999, 2000). The carcass survey utilizes mark and recapture techniques on carcasses, along with three population estimation models, to calculate estimates of escapement (including bounds of confidence) for winter chinook salmon in the upper Sacramento River. Endangered winter-run chinook salmon delisting criteria calls for a geometric mean cohort replacement rate ≥1.0 in addition to abundance ≥ 10,000 female spawners (Botsford and Brittnacher 1998). These delisting criteria allow for uncertainty partially due to limited accuracy in measuring spawner abundance. Estimates of the delisting criteria (cohort replacement rate and female spawned abundance) must be based on at least 13 years of data *assuming* that spawner abundance is measured with less than 25% error (Botsford and Brittnacher 1998). It is currently assumed the RBDD run-size estimates do not provide this level of accuracy, and would therefore necessitate a lengthy time extension prior to commencement of delisting due the increased uncertainty in the estimate. Although winter-run chinook salmon population and run-size estimation methodology associated with the mainstem carcass survey are still undergoing refinement, the potential for the generation of a more accurate estimate than those generated at RBDD is promising.

A second fundamental goal of the winter chinook salmon spawning ground survey is to gather information necessary to evaluate the effectiveness of the U.S. Fish and Wildlife Service's winter chinook salmon hatchery supplementation program. In 1988, a Cooperative Agreement was signed between the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game to implement actions to benefit winter chinook salmon in the Sacramento River basin. Within the Cooperative Agreement, signatory agencies identified a ten-point program of responsibilities and actions to be pursued for the protection and rehabilitation of winter chinook salmon. This Cooperative Agreement, often referred to as "The 10-point Plan," identified development of an propagation program along with associated monitoring and evaluation activities as one of several key elements necessary to benefit winter chinook salmon in the Sacrament River basin. Consequently, an artificial propagation of winter chinook salmon was initiated at Coleman National Fish Hatchery in 1988 to ensure the continued existence of Sacramento River winter chinook salmon. Data collected during spawning ground surveys provides the basis of information to monitor, assess, and recommend improvements to the winter chinook salmon supplementation program and other restoration actions identified in the plan.

Likewise, The National Marine Fisheries Service's Draft Recovery Plan for winter-run chinook salmon identified the hatchery supplementation program as a specific action to assist in the recovery of that species (NMFS 1997). The draft plan identified artificial propagation of winter chinook salmon and improved understanding of winter chinook salmon life history and habitat requirements as two actions necessary for the immediate conservation and future recovery of the species. These recovery actions were assigned Priority I (Research of life history and habitat requirements) and Priority III (Artificial Propagation) based on the established priority system (55 FR 24296). In 1998, partly due to information collected in previous mainstem carcass surveys, the winter chinook propagation program was relocated to Livingston Stone NFH. The Livingston Stone NFH was constructed at the base of Shasta Dam in order to improve imprinting/homing and promote integration of hatchery-origin adults with the natural spawning population of winter chinook salmon in the mainstem Sacramento River. Continued assessment of the effectiveness of this supplementation program to contribute to the recovery of endangered winter chinook salmon is dependent upon information gathered through the Sacramento River mainstem carcass surveys. Information collected/analyzed for the purpose of evaluating the hatchery supplementation program includes: abundance of natural- and hatchery-origin spawners; recovery of coded-wire tagged (hatchery origin) winter chinook salmon; and life history attributes (i.e., age structure, sex ratio, pre-spawning mortality, and spawning success) (Snider et al. 1997, 1998, 1999, 2000; USFWS 1996a; Croci and Hamelberg 1997; Croci et al. 2000). The mainstem carcass surveys allow the generation and comparison of cohort replacement rates of natural- and hatchery-origin winter chinook salmon.

The third primary goal of the Sacramento River spawning ground survey is to collect tissue samples. Tissue samples are collected and analyzed to contribute to refinement of genetic tools to discriminate various races of salmon, estimation of effective population size, general genetic characterization of the winter chinook salmon population, and long-term storage in the CDFG and Service's genetic archives.

Funding for the genetic analysis of tissue samples collected during the carcass surveys is being sought through a separate proposal submitted to CALFED directly by the U.C. Davis' Bodega Marine Laboratory.

All information collected through this survey effort will serve to directly assess AFRP restoration goals for winter chinook salmon, determine the effectiveness of the hatchery supplementation program, and assist in maintaining genetic diversity in hatchery and natural stocks. Additionally, the evaluation of winter chinook salmon spawning in the Sacramento River is an integral part of an agreement between the California Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service's (Service) Central Valley Anadromous Fish Restoration Program (AFRP) to determine habitat requirements for anadromous salmonids. Estimates of spawner abundance generated through the mainstem carcass surveys consistent with this proposal, combined with data collected during concurrent habitat monitoring efforts to identify winter chinook salmon spawning habitat requirements in the upper Sacramento River), contribute to the development of flow recommendations to satisfy requirements of the Central Valley Project Improvement Act, Section 3406(b)(1)(B).

b. Conceptual model

A conceptual model demonstrating the importance of this and other monitoring programs is included on the following page. The model portrays the assumption that restoration actions for winter-run chinook salmon such as those outlined and currently implemented through CVPIA, AFRP and, CALFED, restoration programs will improve degraded habitat conditions that lead to a severely depressed winter-run chinook salmon population. The attached conceptual model also notes the influence of the 1988 Cooperative Agreement signed between the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game to implement actions to benefit winter chinook salmon in the Sacramento River basin. Likewise, the model portrays the Draft Recovery Plan for the Sacramento River Winter-run Chinook Salmon (NMFS 1997). The need for information regarding winter chinook salmon life-history, spawning habitat requirements, and abundance is identified in the Recovery Plan as necessary for the conservation and recovery of the species. Biological data on the spawner population such as age structure, sex ratio, spawning success, and genetic characterization will be obtained directly through this survey effort. The information gathered through surveys of spawning grounds on the upper Sacramento River is also essential for assessing the effectiveness of artificial propagation in supporting the natural winter chinook salmon population while avoiding potential detrimental genetic and ecological effects. Furthermore, genetic material collected during winter chinook salmon spawning ground surveys contributes substantially toward improved run discrimination technology.

Implementation of all restoration actions are designed to reduce stressors and restore and enhance habitat conditions. However, it is only through extensive field monitoring activities such as that outlined in this proposal which will allow for informed adaptive management decision making. Estimates of abundance derived from the Sacramento River winter-run chinook salmon carcass survey and other intensive surveys, such as the juvenile monitoring program, are useful for monitoring cumulative effects of recovery actions and, in the future, long-term, continuous survey data may be used for considerations regarding achievement of doubling goals and/or to satisfy delisting criteria.

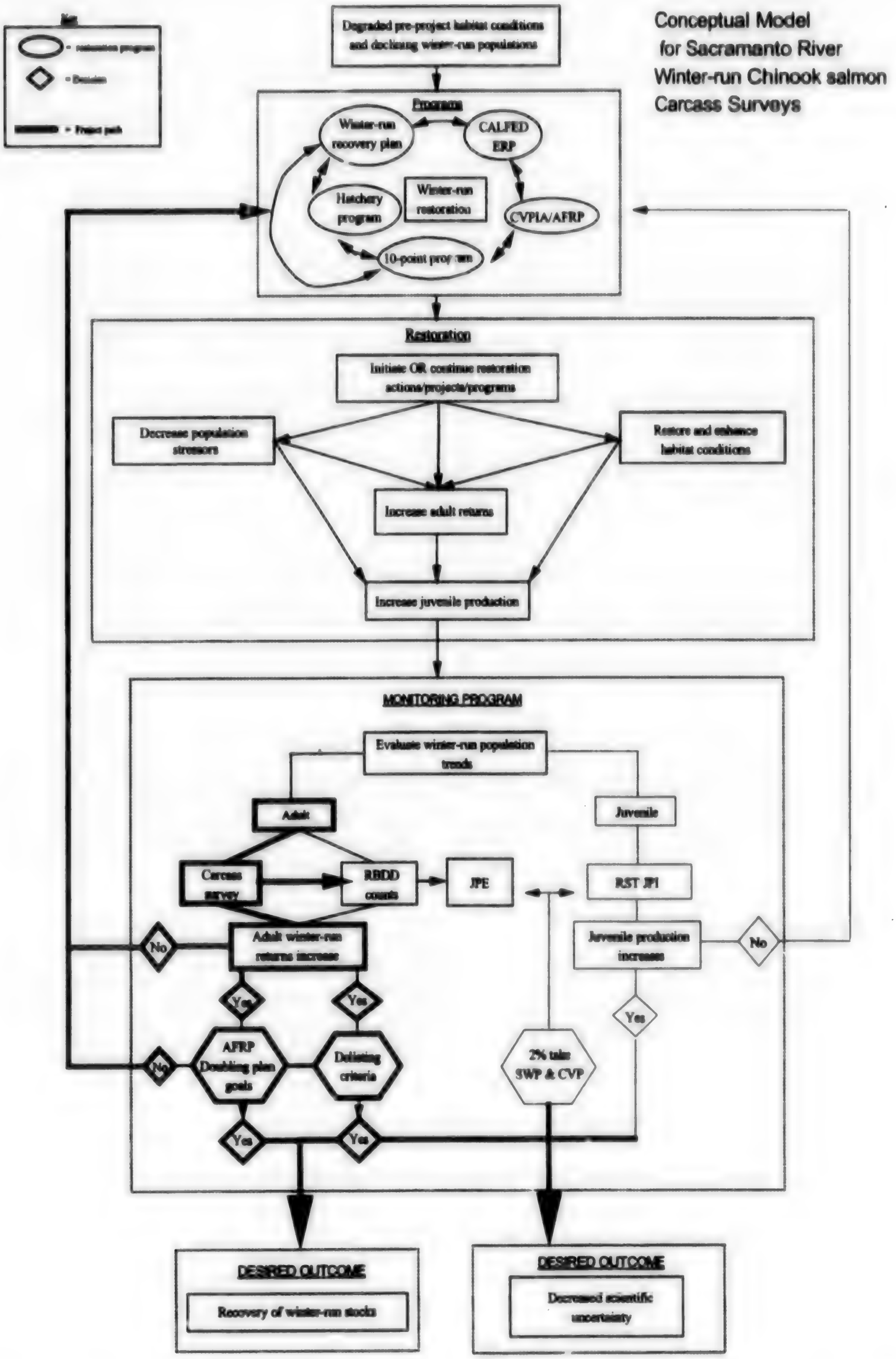
Key
= restoration program
= Decision
= Project path
Degraded pre-project habitat conditions and declining winter-run populations
Conceptual Model for Sacramento River Winter-run Chinook salmon Carcass Surveys
Programs
Winter-run recovery plan
CALFED ERP
Hatchery program
Winter-run restoration
CVPIA/AFRP
10-point program
Restoration
Initiate OR continue restoration actions/projects/programs
Decrease population stressors
Restore and enhance habitat conditions
Increase adult returns
Increase juvenile production
MONITORING PROGRAM
Evaluate winter-run population trends
Adult
Juvenile
Carcass survey
RBDD counts
JPE
RST JPI
Adult winter-run returns increase
Juvenile production increases
No
No
No
Yes
Yes
Yes
AFRP Doubling plan goals
Delisting criteria
2% take SWP & CVP
Yes
Yes
DESIRED OUTCOME
Recovery of winter-run stocks
DESIRED OUTCOME
Decreased scientific uncertainty

Figure 1. Conceptual Model for Sacramento River winter-run chinook salmon carcass surveys

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c. Hypotheses being tested

Information collected during the winter-run chinook salmon mainstem carcass surveys will allow assessment of implemented AFRP, CVPIA and/or CALFED actions and activities. The general hypothesis being tested is that the current run-size estimate is greater than the estimate generated three years previous, assuming an age three maturation schedule for winter-run chinook salmon. Formally stated:

H_0: Winter-run chinook salmon run-size estimate at time (t) > the run-size estimate at time (t-3).

H_a: Winter-run chinook salmon run-size estimate at time (t) ≤ the run-size estimate at time (t-3).

Satisfaction of the null hypothesis would document an increasing trend in the abundance estimate of winter-run chinook salmon and thus support restoration actions and activities as implemented.

Also of prime importance is the development of estimation methodology to satisfy delisting criteria of endangered winter-run chinook salmon:

H_0: Number of winter-run chinook salmon female spawners ≥10,000 and;
Geometric mean cohort replacement rate ≥ 1.0.

H_a: Number of winter-run chinook salmon female spawners <10,000 and/or;
Geometric mean cohort replacement rate < 1.0.

The necessary assumptions to satisfy restrictions of the population estimators suggested for use in this proposal (Jolly Seber and Schaeffer method), have not been met at current population levels (1,000 - 3,000). However, it is expected that at populations levels nearing recovery goals (i.e., approximately 20,000 adults) carcass recovery rates will be sufficient to generate sound estimates within acceptable error rates without increased field effort over that described in this proposal.

Other hypotheses tested through this proposal include the verification of the presence of hatchery-origin winter chinook salmon contributing to the natural spawning population.

H_0: Number of hatchery-origin winter-run chinook salmon successfully spawning >0;

Ha: Number of hatchery-origin winter-run chinook salmon successfully spawning =0; and;

Through genetic analysis conducted through funding of a separate proposal:

H_0: The genetic variability of the winter-run chinook salmon population at time (t) is ≥ the genetic variability at time (t-3).

Ha: The genetic variability of the winter-run chinook salmon population at time (t) is < the genetic variability at time (t-3).

Sound ability to measure the above hypotheses fully support Goal 1-Achieve Recovery of At-Risk Species- as presented in the PSP. Sound methodologies with acceptable error rates are essential to document effects of restoration actions and/or achieve delisting criteria.

d. Adaptive Management -

This proposal describes a monitoring activity designed among other objectives to generate a scientifically defensible run-size estimate for endangered winter-run chinook salmon. As stated previously, the current/previous methodology used to generate run-size estimates for winter-run chinook salmon (Red Bluff Diversion Dam ladder counts), can only examine, on average, the last 15% of the run. Much uncertainty exists, however, in expanding this tail end of the run to generate an actual estimate, as it is known that in some years the percentage examined may be as small as 4.7% or as great as 24.3%. The carcass survey as proposed will use mark and recapture techniques on carcasses, along with three population estimation models, to calculate estimates of escapement (including bounds

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of confidence) for winter chinook salmon in the upper Sacramento River

Accurate estimation of the number of endangered winter-run chinook salmon that return to the upper Sacramento River is critical to provide a direct measure of the success of AFRP and other management activities intended to directly increase population numbers of salmon and steelhead. Mainstem carcass surveys, executed during May though August have distinct advantages over the Red Bluff Diversion Dam (RBDD) estimation method, in that the entire spawning period is encompassed. The collection of information to allow more accurate estimations of population size and structure, will provide the basis for identifying future management actions necessary to accomplish AFRP goals and listed species recovery and delisting.

e. Educational Objectives - Not Applicable.

2. Proposed Scope of Work

a. Location and/or Geographic Boundaries of the Project

The Sacramento River winter chinook salmon spawning ground survey takes place in Shasta County, from Keswick Dam at river mile (RM) 301 downstream to a powerline below Clear Creek Riffle (RM 292). This area, included in CALFED Ecozone 3.1 (Sacramento River, Keswick Dam to Red Bluff Diversion Dam), contains the majority of available spawning habitat for state and federally listed endangered winter chinook salmon (See Figure 2).

b. Approach

The study defined above section is divided into two reaches: 1) upper reach - Keswick Dam to Cypress Street Bridge (RM 302 to RM 295; and, 2) lower reach - Cypress Street Bridge to Redding water Treatment Plant (RM 295 to RM 288).

The Sacramento River winter chinook salmon spawning ground survey will occur from approximately May 1 through August 31 annually. This time period accounts for nearly the entire duration of winter chinook salmon spawning (April - mid-August) in the upper Sacramento River. Field surveys are conducted on a 2-day on / 1-day off survey cycle. For example, the upper reach will be surveyed on the first day and the lower reach on the second day of each 2-day survey cycle. Field sampling will not be conducted on the third day of each cycle. This 2-day on / 1-day off cycle will be repeated throughout the entire survey season.

Field sampling procedures and techniques for the Sacramento River winter chinook spawning ground surveys are described below and further explained in Snider et al. (2000). Most of the survey effort is conducted by boat, utilizing two boats and two observers per boat. Beginning at the downstream boundary of the reach being surveyed, survey teams slowly maneuver the boats upstream while observing for salmon carcasses. Observers from each boat are responsible for surveying along one shoreline out to the middle of the river. Several short stretches of river may be surveyed on foot, as a result of low-water conditions that could be hazardous to boat navigation. Survey effort is intended to sample all areas where salmon carcasses could be located, however, efforts tend to be concentrated in areas where carcasses have been shown to collect through previous survey efforts. Observed carcasses are collected using a gaff or gig.

Most collected carcasses are tagged, except those found in an advanced state of decomposition. Fresh carcasses (those with firm flesh and at least one clear eye) are tagged by attaching a small colored plastic ribbon to the upper jaw with a hog ring. The tag color is used to identify the survey period that the carcass was tagged. Similarly colored tags are applied to the lower jaw of slightly

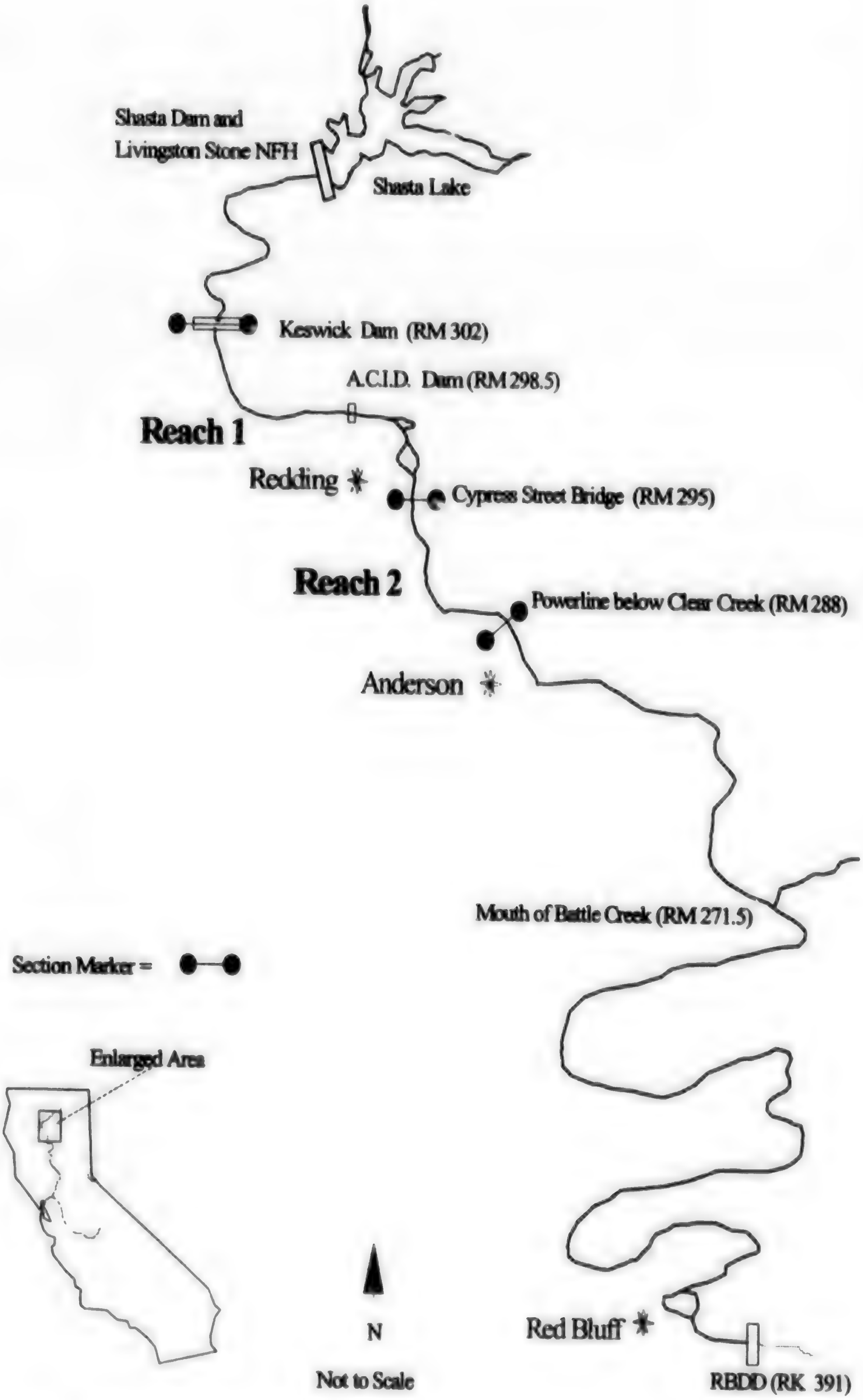

Figure 2. Location of Sacramento River winter chinook salmon carcass survey.

decayed, or non-fresh, carcasses. Carcass condition (fresh or non-fresh) is noted during tagging to accommodate the various population estimators. Carcasses found to be severely decayed are enumerated, cut in two (chopped), and disregarded in subsequent surveys. Data and biological samples are collected from non-chopped carcasses, as described below. Following sampling, collected carcasses are returned to a flowing section of the river, near to the location of carcass collection, in effort to simulate natural patterns of carcass distribution.

Data Collection

Collection date and location are recorded for all carcasses encountered. Fork length, sex, and origin (as determined by mark status: ad-clip=hatchery origin; non-clipped=natural origin) are recorded for all except the most severely deteriorated carcasses. Female carcasses are assessed for egg retention to infer spawning success. Females are considered "completely spawned" if few or no eggs remain in the body cavity, "partially spawned" if a substantial amount (50% or more) of eggs remain, or "unspawned" if they appear to have died prior to depositing any eggs. Water temperature and Secchi disk (water clarity) are measured and recorded daily by the survey crew.

Biological Sample Collection

Biological samples of tissues and scales will be collected from most salmon carcasses encountered during spawning ground surveys. Several samples of soft tissue are collected from the least-decayed area (most often fin or operculum) of most salmon carcasses collected during spawning ground surveys. Tissues are generally not collected from severely deteriorated carcasses because highly-degraded tissues are not useable for genetic analysis. Scales are collected for determination of age composition. Additionally, the head will be collected from adipose fin-clipped (hatchery-origin) carcasses. Coded-wire tags (CWT) are subsequently extracted in the laboratory and read to identify the hatchery of origin.

Population Estimation Methodology

Carcass mark-and-recapture surveys have been routinely used to estimate escapement to Sacramento Valley tributary streams (e.g., American, Yuba, and Feather rivers and Battle Creek). This method was initially used in the Central Valley to estimate the 1973 Yuba River escapement (Taylor 1974). Carcass mark-and-recapture techniques have been used to estimate winter chinook escapement in the Sacramento River since 1996 (Snider et al. 1997).

Three models have been used by the California Department of Fish and Game to estimate escapement from carcass tag-and-recovery data; Petersen (Ricker 1975), Schaefer (1951), and Jolly-Seber (Seber 1982) models. Boydstun (1994) and Law (1994) tested and compared accuracy and precision of these estimators using field-testing and simulated trials, respectively. The Petersen formula is the simplest but least accurate (Law 1992) and has been used primarily when data are insufficient to allow calculation with other models. Law (1992) found that the Petersen model consistently showed substantially larger overestimation than either the Schaefer or Jolly-Seber models. A modified Schaefer model (Taylor 1974) has been used in "larger" Central Valley tributary streams since 1973 when it was first used to estimate escapement in the Yuba River. The Jolly-Seber model was first used in the Central Valley in 1988 to estimate escapement in the Feather, Yuba, American, Stanislaus, Tuolumne, and Merced rivers. While the Schaefer and Jolly-Seber models are generally considered more accurate than the Petersen estimator, a fundamental requirement of the Schaefer and Jolly-Seber models is that tagged fish be recovered during each survey period. This condition has not been satisfied during past survey efforts on the Sacramento River winter chinook salmon carcass survey as a result of low levels of winter chinook abundance (range of Petersen estimates: 820 [1996] to 5,501 [1998]) and relatively low rates of recapture (range: 12% [1997] to 22% [1999]). Therefore, the Petersen formula, using fresh carcass data, has been utilized for calculating winter chinook salmon population estimates since 1996. Although the Petersen formula likely overestimates true abundance, data will likely be available every year to permit calculation of a Petersen estimate, thus allowing for a determination of population trends, unlike the Schaefer and Jolly-Seber models. However, for future years, if we consider a recovering population of winter chinook salmon, then it is likely that requirements of the Schaefer and Jolly-Seber population estimation models will be satisfied. Under this circumstance, these models will be utilized, in combination with the Petersen model, to provide estimates of abundance with increased accuracy and precision. The Department of Fish and Game will continue to refine and enhance survey techniques and statistical methodologies of population estimation using carcass mark-and recovery data.

c. Monitoring and Assessment Plans

The complete proposal as submitted details a monitoring project.

d. Data Handling and Storage

All hard copy data sheets will be retained in office files. Electronic databases will be constructed from field data and will be available from the U.S. Fish and Wildlife Service and/or the California Department of Fish and Game upon completion of required written products.

e. Expected Products/Outcomes

Two annual reports will be generated describing field activities. The California Department of Fish and Game will produce a report that estimates escapement, examines the feasibility of using mark-and-recapture techniques, and describes baseline information on spawning distribution (temporal), environmental conditions at the time of spawning, and size, sex, and success of the spawning population. The Service will generate a report evaluating the winter chinook salmon hatchery propagation program which will include tracking information of genetic samples collected.

f. Work Schedule

The Sacramento River winter-run chinook salmon carcass survey will generally begin on the 1st of May and continue through the end of August. Time frames for all project components as part of Tasks 1 and 2 are presented in Table 1 below. Although Tasks 1 and 2 are separate lines in the budget table (see Section F. Cost), they are actually inseparable and simply denote costs associated with the U.S. Fish and Wildlife Service's aspect of the survey (Task 1), and the California Department of Fish and Game's aspect of the survey (Task 2). Funding and participation of both agencies is critical to meet objectives as presented in this proposal.

Table 1.—Time frame for all project components as part of Tasks 1 and 2.

Tasks 1 and 2	J	F	M	A	M	J	J	A	S	O	N	D
Project set-up				X								
Data collection					X	X	X	X				
Report writing									X	X	X	
Complete report												X

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g. Feasibility

The Service and CDFG have been cooperatively conducting winter chinook salmon carcasses surveys since 1996. Since inception of the joint project, field crews have likely encountered and remedied potential problems or difficulties associated with the monitoring program as described. Inhospitable environmental conditions are always a potential problem but flexibility has been accounted for in the sampling regime. Design constraints and economic impacts are minimal if non-existent. The project has proven successful in generating escapement estimates, suggesting alternatives to hatchery practices and providing samples for genetic analysis. Funding levels as requested through this proposal are expected to be adequate to generate appropriate data. Analytical methodologies are expected to be refined over time to generate run-size estimates with acceptable error rates. These methodology changes may necessitate increased field effort to meet assumptions associated/necessary for the generation of estimates through various population estimators (Jolly Seber and Schaeffer method). Although, it is expected that current field efforts will be sufficient to generate sound estimates due to increasing number of carcass recoveries associated with increases of abundance (see Hypotheses Tested Section above). Previous supplemental funding requests have been made by CDFG, and may, in fact, be made in the future for additional field sampling activities. Additional activities identified include: snokeling, SCUBA, and radio tagging, in effort to increase the number of carcasses recovered.

D. APPLICABILITY TO CALFED ERP GOALS AND IMPLEMENTATION PLAN AND CVPIA PRIORITIES.

1. ERP Goals and CVPIA Priorities.

This project will provide information to document the number of hatchery- and natural-origin winter chinook salmon that return to the upper Sacramento River. Abundance estimates of hatchery- and natural-origin winter chinook salmon resulting from this survey have been generated since 1996 to monitor and assess progress toward goals of the Anadromous Fish Restoration Program (AFRP), the CALFED Bay-Delta Program, the Proposed Recovery Plan for the Winter-run Chinook Salmon, and the "10-Point Plan" to benefit winter chinook salmon. Continuation of the winter chinook salmon spawning ground survey for estimating winter chinook spawner abundance is necessary for continuity in estimation methodology, and to augment questionable estimates spawner abundance generated by fish counts past RBDD.

This survey, as described in this proposal, is designed estimate spawner abundance, which can be used to measure population-level responses (in terms of population size) to cumulative management actions implemented under CALFED, CVPIA, and AFRP. In addition to population level responses, biological information will be collected on individual fish to monitor potential effects on life-history characteristics in response to recovery actions. The following section describes how the winter chinook salmon spawning ground survey will contribute to monitoring progress toward selected goals and priorities of several key restoration programs. Relationships between restoration and supplementation programs and the winter chinook carcass survey are further described in Sections 1(b) and 1(d) which present a conceptual model how information gained through this effort can be used as feedback in an adaptive management framework.

Anadromous Fish Restoration Program

Because of their ESA listing status, Sacramento River winter chinook salmon are considered a high-priority, special status species of the AFRP. To accomplish the AFRP doubling goal, the Department of the Interior has implemented numerous programs to improve environmental conditions and modified operations, management, and physical facilities of the CVP.

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Monitoring, using standardized and validated methods, is essential to obtain data on anadromous fish production and habitats which is used to evaluate the effects of restoration actions. One of the six primary objectives of the AFRP, determined to be important in achieving the overall program goal, is to "[D]evelop fish population, health, and habitat data to facilitate evaluation of restoration actions." Data generated through the Sacramento River spawning ground survey provide arguably the best information available to evaluate effectiveness of restoration actions on winter chinook salmon spawner abundance. Continuation of this program is recommended in the Final Draft Anadromous Fish Restoration Plan (USFWS 1996b), and is considered essential for evaluating the cumulative (systemwide) and long-term effects of AFRP actions taken to double natural production.

Aside from directly the ability to measure achievement of the doubling goal, other aspects of the Anadromous Fish Restoration Program Plan that are supportive of this project: Central Valley-Wide Evaluation #2: *Evaluate the potential to modify hatchery procedures to benefit native stocks of salmonids;* and Central Valley-Wide Evaluation #4: *Evaluate and implement specific hatchery spawning protocols and genetic evaluation programs to maintain genetic diversity in hatchery and natural stocks.*

CALFED Bay-Delta Program

Ecosystem monitoring is identified as a critical step of the ERPP process, providing essential feedback about how the biological system responds to restoration efforts and providing a means to adjust future actions through adaptive management. The success of restoration efforts must ultimately be evaluated through measurement of population-level responses. Ecosystem Restoration Strategic Goal 1 of the CALFED Bay-Delta program places highest priority on restoring populations of at-risk, ESA-listed species, such as winter chinook salmon, which most strongly affect the operation of the State Water Project and Central Valley Project diversions in the south Delta. Ultimately, the time-line for satisfying delisting criteria for winter chinook salmon is dependent upon the accuracy of population estimates using standard methods. For winter chinook salmon, population estimation using information derived from the Sacramento River spawning ground survey is critical to gauge progress toward achieving recovery goals.

2. Relationship to Other Ecosystem Restoration Projects.

As Explained above and in the conceptual model the project as described has the potential to document the effectiveness of past and future CALFED, AFRP, CVPIA and other ecosystem restoration activities.

3. Requests for Next-Phase Funding.

See Appendix I.

4. Previous Recipients of CALFED or CVPIA funding.

The U.S. Fish and Wildlife Service has previously received funding for this project through an AFRP entitled: *Expanded winter-run chinook salmon carcass survey: Upper mainstem Sacramento River.* The Department of Fish and Game has also received previous funding for this project through AFRP and CVPIA. The title of CDFG's AFRP proposal is: *Winter-run chinook salmon escapement survey, Sacramento River.* Other funding for CDFG was secured through CVPIA/AFRP as part of the AFRP project entitled: *Continue to conduct instream flow studies on the Sacramento, American, and Merced rivers.* See Appendix I for status update.

5. System-Wide Ecosystem Benefits.

As explained above the project as described has the potential to document the effectiveness of past and future CALFED, AFRP, CVPIA and other ecosystem restoration activities. Additionally, this program intimately ties into other projects also requesting funding through this PSP. While this project is largely aimed at developing a run-size estimate for endangered winter-run chinook salmon, a juvenile monitoring program executed by the U.S. Fish and Wildlife Service at the Red Bluff Diversion Dam will attempt to corroborate run-size estimates with juvenile production estimates (JPE). Upon generation of a precise JPE, general life-history production models can be used to generate estimates of egg deposition and contributing numbers of females which can be compared to run-size estimates generated through carcass surveys and Red Bluff Diversion Dam fish ladder counts. In combination, the carcass survey results and the JPE will result in a reduction in scientific uncertainty, and can be used to assess success of spawner contribution leading to a more complete measure of habitat productivity.

The carcass survey project as described in this proposal also supports investigations into the genetic variability of endangered winter-run chinook salmon by collecting large numbers of tissue samples of this endangered species. These samples will be analyzed through a proposal submitted by U.C. Davis' Bodega Marine Laboratory. Tissue samples collected through the mainstem carcass surveys will go to support measurements of effective population size and population genetic integrity, as outlined in Bodega Marine Laboratory's proposal.

E. QUALIFICATIONS.

U.S. Fish and Wildlife Service Applicant Qualifications

James G. Smith.-Mr. Smith is the Project Leader at the Service's Northern Central Valley Fish and Wildlife Office (NCVFWO) in Red Bluff, California. The NCVFWO been extensively involved with monitoring chinook salmon in the Northern Sacramento River since 1978, and has been involved in the Sacramento River winter-run chinook salmon carcass survey since 1994. The office is staffed with approximately 40 personnel, and has responsibilities that include identifying and defining factors affecting the abundance and survival of anadromous salmonids in the Sacramento River Basin. Mr. Smith has a B.S. from Humboldt State University (1975) and conducted post-graduate study in Fisheries also from Humboldt State University (1976-1979). Mr. Smith has been with the U.S. Fish and Wildlife Service for 21 years, and for the past 17 years, has been involved with numerous fishery studies directly in the upper Sacramento River (e.g., investigations at RBDD, monitoring juvenile outmigrants, hatchery evaluation efforts at Coleman NFH, Battle Creek restoration, and mainstem Sacramento River spawning gravel evaluations). Mr. Smith works on a daily basis with numerous federal, state, and private entities in developing actions and programs for restoring, conserving, and enhancing anadromous salmonids in the upper Sacramento River.

Scott Hamelberg- Mr. Hamelberg has a B.S. in Environmental Science from Northland College (1983). He has been with the U.S. Fish and Wildlife Service for 17 years, 9 of which have been out of the Red Bluff office where he is the Assistant Project Leader. His main responsibilities include the evaluation of Coleman and Livingston Stone NFHs and involvement in the winter-run chinook salmon propagation and captive breeding programs. The mainstem Sacramento River carcass surveys have been conducted out of the Hatchery Evaluation program led by Mr. Hamelberg.

The California Department of Fish and Game Applicant Qualifications

Bill Snider-- Project co-manager. Mr. Snider is a graduate of the University of California at Davis and has 28 years of experience with DFG, including 20 years experience with the Stream Evaluation Program. During the past four years, Mr. Snider has been the project manager of the Sacramento River stream habitat evaluation project while the project has conducted annual spawner escapement surveys on winter run as well as fall and late-fall run.

Robert Reavis– Project co-leader. Mr. Reavis is a graduate of Humboldt State University and has 34 years experience with DFG including regional salmon management coordinator and district biologist for the anadromous fisheries within Region 2. Mr. Reavis has over 25 years experience in conducting, coordinating and leading salmon escapement surveys throughout the Central Valley.

Scott Hill– Oversee field activities. Mr. Hill is a graduate of Humboldt State University and has 8 years of experience with the DFG. Mr. Hill has been the principle field investigator on the Sacramento River stream habitat evaluation project for the past 4 years during which time he has conducted salmon escapement surveys for winter, fall and late-fall run.

F. COST

1. Budget.

See Table 2 for a detailed budget for each year of requested support, and a summary budget detailing requested support for the overall project period (3 years). This project, however, should be expected to go substantially into the future to monitor the response of endangered winter-run chinook salmon abundance as a result of actions and activities implemented under AFRP, CVPIA, CALFED, and/or other restoration.

Please note that in examination of the budget Task 1 and 2 are inseparable and simply denote the funding required by the U.S. Fish and Wildlife Service (Task1) and the California Department of Fish and Game (Task 2). Upon approval of this proposal, a Cooperative Agreement will be developed between the U.S. Fish and Wildlife Service and the California Department of Fish and Game to provide a mechanism for the funding transfer. Detail of Salary and benefit breakdowns are displayed in Tables 3 and 4.

Motor Boat Operators Training is required for Fish and Wildlife Service employees and is estimated at $1,000 in the initial year. Supplies and expendable materials for both agencies include boat gas and oil, life vests, gigs or gaffs, and tissue vials. Other equipment includes vehicle lease, and partial funding for a project computer.

Budget computations for U.S. Fish and Wildlife Service participation (Task 1) include an inflation rate of 4% is applied across the board for years 2 and 3, while at 5% infaltion rate is used in budget computations for California Department of Fish and Game (Task 2).

2. Cost-Sharing. None

Table 2.-Annual and Total Budget

Year	Task*	Subject to Overhead						
		Salary and Benefits	Training, Travel and Per Diem	Vehicle Gas and Mileage, Supplies & Expendables	Equipment Including Vehicle and Computer Purchases	Service Contracts	Overhead **	Total Cost
Year 1	Task 1	$36,480	$1,000	$6,900	$3,000	$0	$1,421	$48,801
	Task 2	$29,356	$0	$5,200	$2,000	$0	$8,408	$44,964
Total Cost Year 1		**$65,836**	**$1,000**	**$12,100**	**$5,000**	**$0**	**$9,829**	**$93,765**
Year 2	Task 1	$43,263	$1,040	$7,176	$3,120	$0	$1,638	$56,237
	Task 2	$30,824	$0	$5,460	$2,100	$0	$8,828	$47,212
Total Cost Year ***		**$74,087**	**$1,040**	**$12,636**	**$5,220**	**$0**	**$10,466**	**$103,449**
Year 3	Task 1	$44,994	$1,082	$7,463	$3,245	$0	$1,703	$58,486
	Task 2	$32,365	$0	$5,733	$2,205	$0	$9,270	$47,573
Total Cost Year 3***		**$77,359**	**$1,082**	**$13,196**	**$5,450**	**$0**	**$10,973**	**$108,059**
Total Project Cost		$217,281	$3,122	$37,932	$15,670	$0	$31,269	$305,273

* Task only denotes split cooperation between U.S. Fish and Wildlife Service (Task 1), and California Department of Fish and Game (Task 2)

** Overhead for U.S. Fish and Wildlife Service shown at 3%.
Overhead for California Department of Fish and Game calculated at 23%

***Cost of living increases calculated at 4% for U.S. Fish and Wildife Service, and 5% for California Department of Fish and Game

Table 3- U.S. Fish and Wildlife Salary and Benefit costs associated with carcass survey by position

Task 1/Year 1	Position*	Annual Salary	Annual Benefits	Total	Time (Years)	TOTAL
	GS-5	$23,731.76	$1,827.35	$25,559.11	0.333	$8,511.18
	GS-5	$23,731.76	$1,827.35	$25,559.11	0.333	$8,511.18
	GS-7	$29,395.60	$2,263.46	$31,659.06	0.167	$5,287.06
	GS-9	$38,355.20	$10,547.68	$48,902.88	0.100	$4,890.29
	GS-11	$46,407.92	$12,762.18	$59,170.10	0.050	$2,958.50
	Other	$34,254.95	$7,887.29	$42,142.24	0.150	$6,321.34
					1.133	**$36,479.56**

Task 1/Year 2	Position*	Salary	Benefits	Total	Time	TOTAL
	GS-5	$25,503.05	$6,324.76	$31,827.80	0.333	$10,598.66
	GS-5	$25,503.05	$6,324.76	$31,827.80	0.333	$10,598.66
	GS-7	$31,589.21	$7,834.12	$39,423.33	0.167	$6,583.70
	GS-9	$39,889.41	$10,969.59	$50,859.00	0.100	$5,085.90
	GS-11	$48,264.24	$13,272.67	$61,536.90	0.050	$3,076.85
	Other	$35,625.15	$8,202.78	$43,827.93	0.167	$7,319.26
					1.150	**$43,263.02**

Task 1/Year 3	Position*	Salary	Benefits	Total	Time	TOTAL
	GS-5	$26,523.17	$6,577.75	$33,100.91	0.333	$11,022.60
	GS-5	$26,523.17	$6,577.75	$33,100.91	0.333	$11,022.60
	GS-7	$32,852.78	$8,147.49	$41,000.27	0.167	$6,847.04
	GS-9	$41,484.98	$11,408.37	$52,893.36	0.100	$5,289.34
	GS-11	$50,194.81	$13,803.57	$63,998.38	0.050	$3,199.92
	Other	$37,050.15	$8,530.90	$45,581.05	0.167	$7,612.03
					1.150	**$44,993.54**

* All "GS" positions are fishery biologists. Other includes: administrative officer, office automation clerk, maintenance worker, etc.. Includes 4% cost of living adjustment for years 2 and 3. GS-5 and 7 positions also reflect change from "Temp" to "Term" status in years 2 and 3.

Table 4--California Department of Fish and Game salary and benefit costs associated with Carcass survey by position

Task 2/Year 1	Position	Annual Salary	Annual Benefits	Total	Time (Years)	TOTAL
	Sci Aid	$23,812.00	$1,810.00	$25,622.00	0.333	$8,532.13
	Sci Aid	$23,812.00	$1,810.00	$25,622.00	0.333	$8,532.13
	Sci Aid	$23,812.00	$1,810.00	$25,622.00	0.333	$8,532.13
	Sci Aid	$23,812.00	$1,810.00	$25,622.00	0.150	$3,843.30
					1.15	**$29,439.68**

Task 2/Year 2	Position	Salary	Benefits	Total	Time	TOTAL
	Sci Aid	$25,002.60	$1,900.50	$26,903.10	0.333	$8,958.73
	Sci Aid	$25,002.60	$1,900.50	$26,903.10	0.333	$8,958.73
	Sci Aid	$25,002.60	$1,900.50	$26,903.10	0.330	$8,878.02
	Sci Aid	$25,002.60	$1,900.50	$26,903.10	0.150	$4,035.47
					1.15	**$30,830.95**

Task 2/Year 3	Position	Salary	Benefits	Total	Time	TOTAL
	Sci Aid	$26,252.73	$1,995.53	$28,248.26	0.333	$9,406.67
	Sci Aid	$26,252.73	$1,995.53	$28,248.26	0.333	$9,406.67
	Sci Aid	$26,252.73	$1,995.53	$28,248.26	0.333	$9,406.67
	Sci Aid	$26,252.73	$1,995.53	$28,248.26	0.150	$4,237.24
					1.15	**$32,457.24**

Includes 5% cost of living adjustment for years 2 and 3; salary $11.41/hr and benefits at 7.65% in year 1 is at top of scientific aid scale.

G. LOCAL INVOLVEMENT

CDFG shares equally in the implementation of this project with the Service at NCVFWO. Instead of a single local watershed group with an interest in this project, this mainstem Sacramento River project is broadly supported by multiple watershed groups throughout the Sacramento River Watershed. This project does not contribute to development or implementation of any specific locally led watershed planning efforts, however, the reports of the winter-run chinook salmon mainstem carcass survey are of interest to many local watershed groups (e.g. Clear Creek, Cow Creek, Cottonwood Creek, Battle Creek).

H. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

The Fish and Wildlife Service (Service) cannot agree to a standard clause requested for State funded projects. Attachment D, Terms and Conditions for State Proposition 204 Funds, Section 3, states "Performance Retention: Disbursements shall be made on the basis of costs incurred to date, less ten percent of the total invoice amount. Disbursement of the ten percent retention shall be made either: (1) upon the Grantee's satisfactory completion of a discrete project task (ten percent retention for task will be reimbursed); or (2) upon completion of the project and Grantee's compliance with project closure requirements specified by CALFED (ten percent retention for entire project will be disbursed)".

The Service's authorization to enter into agreements with non Federal entities was changed in FY 2000. Our FY2000 Appropriations bill authorizes the Service to enter into contracts with State agencies when advance payment to the Service is not possible. In accordance with the requirements imposed by Congress in the FY2000 Appropriations bill and report language, the Services Director must approve a project when advance payment is not possible and certify that payments will be made in full by the State within 90 days after the Service issues an invoice. Specifically, the 10% retention clause cannot allow timely payments for the following reasons:

In our Federal Financial System (FFS) accounting program, a periodic invoice (either quarterly or monthly depending on the terms of the contract) is automatically issued from our finance center based on actual expenditures of the Service on a project. Invoices include a payment due date on the invoice and when payment is not received in full by that due date, the system automatically shows the unpaid balance as delinquent. Depending on how delinquent the payment is, interest, penalty and administrative charges may also accrue. With 10% retention withheld on each invoice, the 10% retention amount then causes applicable invoice record in FFS to be partly delinquent and remain delinquent until the project or individual tasks identified in the contract are completed and the retention is released.

The Service's Finance Center must report to the Department of Treasury if the Service is owed funds by any entity. Therefore, when accounts remain delinquent due to the 10% retention of payments owed the Service, that delinquency continues to be reported to Treasury.

The Service has previously entered into agreements with the State of California that do not contain the 10% retention clause.

We have asked the States Deputy Attorney General (see attached letter) to provide clarifying guidance to the Department of Water Resources that is general in scope, which can also be applied to contracts related to the CALFED program.

Our offices will continue to work with the State closely on State funded projects. If the State is not satisfied with the work performed by the Service, the State project manager should contact the Service's project manager to correct the performance problem. If needed, upon notification interim billings can be canceled until the State is satisfied with the Services performance. We can comply with all other State and Federal standard clauses.

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Other Applicable Publications

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ENVIRONMENTAL COMPLIANCE CHECKLIST

1. Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both? **YES.**

2. If you answered yes to # 1, identify the lead governmental agency for CEQA/NEPA compliance. **Fish and Wildlife Service.**

3. If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal. **NA see # 1.**

4. If CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion. **The type of proposed monitoring projects are categorically excluded in the Fish and Wildlife Service Departmental Manual at 516 DM 6 Appendix 1.4 Categorical Exclusions Section B. Resource Management: (1) Research, inventory, and information collection activities directly related to the conservation of fish and wildlife resources.**

5. Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal? If yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to include written permission for access may result in disqualification of the proposal during the review process. Research and monitoring field projects for which specific field locations have not been identified will be required to provide access needs and permission for access with 30 days of notification of approval. **No.**

6. Please indicate what permits or other approvals may be required for the activities contained in your proposal. Check all boxes that apply.

Conditional use permit ___
Variance ___
Subdivision Map Act approval ___
Grading permit ___
General plan amendment ___
Specific plan approval ___
Rezone ___
Williamson Act Contract cancellation
Other ________(please specify)
None required ___

STATE

CESA Compliance XXX
Streambed alteration permit ___
CWA § 401 certification ___
Coastal development permit ___
Reclamation Board approval ___
Notification ___
Other- Scientific Collection permit
None required ___

FEDERAL

ESA Consultation XXX (NMFS)
Rivers & Harbors Act permit ___
CWA § 404 permit ___
Other _______(please specify)
None required ___

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LAND USE CHECKLIST

1. Do the actions in the proposal involve physical changes to the land(i.e. grading, planting vegetation, or breeching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)? **NO.**

2. If NO to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only). **The monitoring projects will not involve physical changes to the land.**

3. If YES to # 1, what is the proposed land use change or restriction under the proposal? **NA see # 1.**

4. If YES to # 1, is the land currently under a Williamson Act contract? **NA see # 1.**

5. If YES to # 1, answer the following: current land use, current zoning, current general plan designation: **NA see # 1.**

6. If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps? **NA see # 1.**

7. If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal? **NA see # 1.**

8. If YES to # 1, is the property currently being commercially farmed or grazed? **NA see # 1.**

9. If YES to #8, what are the number of employees/acre, the total number of employees **NA see # 1.**

10. Will the applicant acquire any interest in land under the proposal (fee title or a conservation easement)? **NO.**

11. What entity/organization will hold the interest? **NA see # 1.**

12. If YES to # 10, answer the following total number of acres to be acquired under proposal, number of acres to be acquired in fee, number of acres to be subject to conservation easement. **NA see # 10.**

13. For all proposals involving physical changes to the land or restriction in land use, describe what entity or organization will: manage the property, provide operations and maintenance services, conduct monitoring. **NA see # 10.**

14. For land acquisitions (fee title or easements), will existing water rights be acquired? **NA see # 10.**

15. Does the applicant propose any modifications to the water right or change in the delivery of the water? **NA see # 10.**

16. If YES to # 15, describe. **NA see # 10.**

Section D

3. Requests for Next-Phase Funding

Status/history of generation of winter-run chinook salmon run-size estimates. AFRP/CVPIA began funding the survey in 1996.

1971- 1986

Red Bluff Diversion Dam (RBDD) (RM 243) was in year-round operation (i.e. gates are down -- causing a low head dam to divert a portion of the Sacramento River down the Tehama-Colusa Canal). Winter chinook salmon escapement estimates were based on counts at the three fish ladders that provide passage around the dam. These counts encompassed the entire winter chinook salmon migration period (December through early July) allowing a complete accounting of the winter chinook salmon escapement.

1987 A major effort to restore winter chinook salmon populations consisted of operational changes to RBDD. Instead of the dam gates at RBDD being in operation all year (i.e. migration barrier), the dam gates are only lowered into operation from May through September. This improves conditions for adult and juvenile salmonid passage at the dam, but the ability to effectively estimate escapement of all runs of salmon was greatly reduced.

1988 The Service entered into a mutual agreement with National Marine Fisheries Service, U.S. Bureau of Reclamation, and CDFG to develop a winter chinook hatchery propagation program at the Service's Coleman National Fish Hatchery, located on Battle Creek. This program was established to ensure the continued existence of the Sacramento River winter chinook salmon. The goal of the propagation program was to supplement natural spawning while avoiding the development of an adult return to the hatchery.

1994 A pilot winter-run chinook salmon carcass survey on the mainstem Sacramento River began as a means to evaluate the winter chinook salmon propagation program and to collect tissue samples for genetic analysis. During this initial year, minimal effort was afforded by conducting boat surveys to locate carcasses particularly around Turtle Bay (RM 298). Also, boats were deployed to recover carcasses observed during weekly aerial flights from May through August to count winter chinook salmon redds. Twelve carcasses were recovered in 1994, which accounted for approximately 6% of the estimated run past Red Bluff Diversion Dam (RBDD). No hatchery-origin winter chinook salmon were observed.

1995 The Service put forth more effort to recover winter chinook salmon carcasses to determine the success of the propagation program, and collect tissues for genetic characterization of the winter-run chinook salmon population for run discrimination work and in support of the propagation program. One boat with two people went out once a week to look for carcasses in the Redding area from May through August. A total of approximately 117 winter chinook salmon carcasses were recovered amounting to 8.6% of the estimated run size past RBDD. Again, no hatchery origin winter chinook salmon were observed.

Section D
3. Requests for Next-Phase Funding

1996 A cooperative effort between the Service and CDFG to conduct winter chinook salmon spawning ground surveys was developed in 1996. This "expanded" effort was funded through the Service, AFRP and CVPIA. The 1996 expanded surveys included two crews (two boats and two people per boat) surveying from Keswick Dam (RM 301) downstream to the mouth of Battle Creek (RM 272) from May through August. This area was divided into 4 different sections and each section was surveyed only once per week. In addition to looking for hatchery-origin winter chinook salmon and collecting tissue samples for genetic analysis, a carcasses mark-and-recapture technique was used to estimate escapement. Approximately 130 carcasses were collected and, again, no hatchery origin winter chinook salmon were observed. The escapement estimate using carcass mark-and-recapture was 820 compared to the 940 estimated using RBDD counts.

1997 Effort was again expanded (i.e. co-staffed and funded by the Service and CDFG) in an attempt to tag and recover more carcasses and also concentrated to locations near Redding, Keswick Dam downstream to Clear Creek Riffle (RM 288). Approximately 240 carcasses were collected. Four hatchery-origin winter chinook were encountered. The escapement estimate using carcass mark-and-recapture was 2,053 compared to 841 using RBDD counts.

1998 A continued cooperative effort (Service and CDFG) surveyed from Keswick Dam downstream to the Clear Creek Riffle. Approximately 785 carcasses were collected, and four hatchery-origin winter chinook salmon were collected. The escapement estimate using carcass mark-and-recapture was 5,501 compared to 2,612 using RBDD counts.

1999 A continued cooperative effort (Service and CDFG) surveyed from Keswick Dam downstream to the Clear Creek Riffle. Approximately 475 carcasses were collected including 5 hatchery-origin winter chinook salmon The escapement estimate using carcass mark-and-recapture was 1,821 compared to 3,208 using RBDD counts.

2000 Surveys in progress (Initiated on 3 May 2000).

CERTIFICATION AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the foregoing information is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this Biological Assessment is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Mary Ellen Mueller

Mary Ellen Mueller
California/Nevada Fisheries Supervisor

RESPONSES TO COMMENTS

15.1 Genetic and ecological effects

Comment 1: Domestication and relaxed selection should have received more attention. Presumptions of minimal deleterious interactions between hatchery and wild fish should be recognized as untested hypotheses, and seem to contradict data from other salmonid studies.

Sub Comment 1 - Evidence for genetic similarity between hatchery and natural populations ignores the fact that molecular data provide evidence of gene flow, not adaptive differences. Meaning markers used for genetic studies are usually selectively neutral, so would not reveal adaptive differences.

Sub Comment 2 - There is little doubt that adaptive differences would be present if hatchery stock did not continually swamp wild stock.

Sub Comment 3 - Except where low or declining population size threatens the persistence of wild populations, conservation (in terms of maximizing fitness and resilience) should best be served by preventing hatchery fish from interbreeding with wild fish. (Reg states his belief that steelhead recovery would best be served by not passing hatchery steelhead above the barrier weir after a few generations.)

Response: An appendix has been added (Appendix 6D) to address the genetic management strategy employed at Coleman and Livingston Stone NFH's. The appendix also discusses issues of domestication and relaxed selection, and integration between hatchery and natural populations.

Comment 2: The draft BA discusses effects of juvenile releases, but does not discuss possible predation by resident trout on hatchery or natural juveniles.

Response: The primary purpose of the BA is to describe hatchery facilities and operations, and to address potential impacts of the hatchery programs on natural fish populations in Battle Creek or the upper Sacramento River. However, it is possible that chinook salmon and steelhead trout from Coleman NFH could be impacted by, and in-turn provide a benefit to, other species or conspecifics, including: other fish species (e.g., resident trout, Sacramento pike-minnow), aquatic mammals (e.g, seals, sea lions, otters), water fowl (e.g., mergansers) and other shore birds (egrets and herons). Chinook salmon and steelhead trout from

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Coleman NFH serve as a potential source of food that would be otherwise unavailable due to the decline of natural salmonid populations.

Comment 3: The draft BA does not adequately discuss effects of Coleman NFH operations or production on natural populations. Analyses and condition information are presented but effects need to be discussed in more detail (e.g., what impact will removing 1,000 juvenile steelhead trout have on the population as a whole?).

Response: The primary purpose of the BA is to describe the Service's artificial propagation programs at Coleman and Livingston Stone NFH's and to estimate incidental take of listed species resulting from those activities. To this end, qualitative and quantitative (where possible) estimates of take are generated. Based on these take estimates, the Service suggests that the overall impact on the populations is generally minimal. However, the National Marine Fisheries Service must actually review and analyze the programs and take estimates. Based on the information provided in the BA, the NMFS will prepare a Biological Opinion that will determine whether the activities as described will jeopardize the existence of listed species.

Comment 4: Hatchery-origin fall chinook salmon that are allowed to spawn naturally in Battle Creek may actually be reducing the viability of the natural stock, resulting in decreased smolt to adult survival even if there are increases in over-all juvenile production.

Response: While we have evidence that hatchery-origin adults spawning naturally in Battle Creek are spawning successfully and providing high levels of juvenile production, we currently have few data on rates of adult returns as a result of natural production in lower Battle Creek. For example, in the California Department of Fish and Game's Grand Tab database, it is estimated that 10% of the fall chinook salmon adults returning to Coleman NFH are of natural-origin. Additionally, in some years, the percentage of non-marked adults exceeded the percentage expected based on initial marked to non-marked ratios of released hatchery juveniles. This suggests adults of natural-origin were also present in lower Battle Creek. The data used to generate these estimates, however, are not very robust. Therefore, although many juveniles are being produced in the system, continued and expanded monitoring of juvenile production and adult escapement in Battle Creek, and perhaps increased marking rates, will be required to provide the data needed to answer this question. Since the existing limited data are unable to indicate either increased or decreased survival from hatchery-origin adults allowed to spawn in the wild, we have amended our previous statement by adding the following:

However, it is not currently known if this high level of juvenile production will result in similar levels of adult returns. (Section 2.10, page 2-17)

Comment 5: The draft BA focuses on the area around the hatchery and the upper Sacramento River. What about the rest of the Sacramento River system?

Response: Hatchery activities and operations likely have the greatest impact on natural fish populations present in Battle Creek and the upper Sacramento River. Consequently, we focused our analyses on this area. Interactions between hatchery and natural stocks undoubtedly occur in the lower Sacramento River, the Delta, and in the ocean. Unfortunately, effects of these interactions are largely speculative or unknown.

Comment 6: Brief mention is made of straying of hatchery late-fall chinook salmon that are released in the Delta. Since stray rates of off-site releases are higher, Delta releases may pose increased genetic and ecological risks to natural populations; therefore, a more in-depth discussion of Delta strays is warranted.

Response: Hatchery fish released at distant down-stream locations do have an increased tendency for straying. The Service releases a portion of the late-fall production at various downstream locations at the request of other agencies and researchers for the purpose of investigating factors influencing salmonid survival (e.g., export rates, flow, tides, diversion operations). Researchers requesting non-standard release conditions for Coleman NFH fish (e.g., non-typical locations, times, or life-stage) are required to obtain permission from the NMFS and CDFG prior to the actual release. Before granting approval, NMFS and CDFG weigh the value of the information to be gained with the potential risks of each release. If, in the opinion of the Service, CDFG, and NMFS, the value of the research does not outweigh the risks of the release, permission to go through with the off-site release would not be granted and the Service would not follow through with the release. For the delta releases of late-fall chinook in question, the potential benefits to be gained through the research has been considered to justify the increased straying occurring as a result of the off-site releases.

A paragraph concerning increased stray rates associated with Delta releases of late-fall chinook salmon produced at Coleman NFH has been incorporated in Section 10.12 (subsection entitled 'Potential Risks from Straying of Hatchery Salmonids'). Appendix 10C presents the Service's analysis of straying of hatchery fish and includes a discussion of potential genetic impacts of hatchery strays.

Comment 7: How was the estimate of stray rate (given as approximately 10%) derived? Is this high?

Response: Estimates of stray rates in natural populations have been reported to range from <1% to 25% (Shapovalov and Taft 1954, Quinn et al. 1987, Labelle 1992). While the Service's recent analysis of straying did not attempt to determine stray rates for on-site releases, information is available to suggest it is not zero, but is likely no greater than 10% (Cramer 1991, Sholes and Hallock 1979). This is well within the range reported for natural populations. See Appendix 10C for more information on the Service's analysis of straying by hatchery fish and a discussion of potential genetic impacts of hatchery strays.

15.2 Disease transmission

Comment 8: The BA appears to dismiss disease problems that might result from high levels of carcasses and therefore pathogens downstream from Coleman NFH based primarily on one year of sampling. This question bears continued investigation because negative results in one year do not preclude serious epizootics in other years.

Response: The Service is not aware of any evidence for disease transmission to natural salmonids from infected adult carcasses in Battle Creek, but we recognize the potential for disease transmission via that mode. It is important to note that IHNV is indigenous to the upper Sacrament River system. IHNV is readily detectable in natural as well as hatchery stocks including: winter, late-fall, and fall chinook carcasses collected in the upper Sacramento River. However, previous monitoring efforts by the CA-NV FHC (over three years) have yielded no evidence for disease transmission to juvenile salmonids from large numbers of IHNV-infected carcasses in the upper Sacramento River (S. Foott, pers. comm.). Regardless, the Service intends to continue monitoring juvenile salmonids in Battle Creek for IHNV. By doing this, epizootics associated with high densities of infected adult carcasses would hopefully be detected. Furthermore, it is noteworthy that IHNV has not been detected in fall chinook at Coleman NFH since the completion of the ozone water treatment plant. Releasing IHNV-free juveniles may result in little to no IHNV in returning adults (depending on interactions with infected stocks), alleviating concerns about spreading pathogens from carcasses of hatchery-origin adults to juveniles in Battle Creek. Risk of IHNV transmission to juveniles from adult carcasses is discussed in Section 3.7 and Appendix 3D. Risk of disease transmission to natural juveniles from infected hatchery juveniles is discussed in Section 10.5.

Comment 9: No mention is made of pathogen loads in hatchery effluent associated with epizootics at Coleman NFH. Is this because hatchery effluent is treated? Where does effluent (presumably infected with IHNV) from hatchery spawning and holding go? What are impacts to natural stocks from hatchery effluent?

Response: Adult ponds discharge into the Coleman fish ladder, production ponds discharge directly into Battle Creek except during cleaning operations when effluent with suspended solids is diverted into the abatement pond. Currently, no effluent is treated.

Risks to natural populations from hatchery effluent should be low for three main reasons. First, with the construction of the ozone treatment plant, concerns about epizootics at Coleman NFH should be largely alleviated. Therefore, pathogen loads, at least from production ponds, should be minimal. Second, two years of sentinel studies (holding juvenile fall chinook with IHNV-infected late-fall adults in the Coleman NFH holding ponds) have shown no transmission of IHNV (s. Foott, pers. com.). In addition, no IHNV was detected in naturally-produced fall chinook fry from Battle Creek, despite their close association with IHNV-infected adult fall chinook carcasses (Foott 1996b). Third, laboratory studies to examine IHNV transmission from infected hatchery to natural fall chinook salmon showed no transmission of IHNV to natural-origin salmon, even when ratios of infected hatchery fish to uninfected natural fish were 20 to 1 (Foott et al. 2000). Further, no IHNV-infected juveniles of natural-origin have been collected from Battle Creek and the Sacramento River during regular pathogen monitoring surveys (S. Foott pers. comm.). Lastly, hatchery effluent typically comprises a small proportion of the total Battle Creek flow, so any pathogens in the hatchery effluent are diluted. See section 10.5 for a more complete discussion of disease and disease transmission.

Comment 10: A discussion of effects of infected hatchery juvenile chinook on natural juvenile chinook is presented, but the draft BA should also discuss the effects of infected adult chinook on natural chinook juveniles. In particular, discussion of potential impacts to outmigrating spring chinook is lacking. Have longer-term studies been conducted to determine if naturally produced juveniles passing through IHNV-infected spawning areas become infected?

Response: The Service does discuss the possibility of transmitting infectious diseases (particularly IHNV) from infected carcasses to naturally-produced juvenile chinook in Battle Creek. Laboratory experiments conducted at the Service's CA-NV FHC (Foott et al. 2000) showed no transmission of IHNV from infected hatchery chinook to natural chinook, despite high ratios of infected to uninfected fish and purposeful stressing (net stressing). They concluded that the local strain of IHNV had low virulence and, therefore, posed limited risks of transmission to natural populations. This topic is discussed further in a subsection of Section 10.5 (Transmission of IHNV from Hatchery- to Natural-origin Salmonids after Release). A brief discussion is also presented in Section 3.7.

Comment 11: Is there a detrimental effect from delayed emigration below the barrier weir or commingling in disease transmission? In other words, does delayed migration at the barrier weir or commingling with infected adults increase risks of disease transmission?

Response: Any increase in exposure time or concentration of a pathogen would increase risk of transmitting IHN from infected adults to juveniles. However, data are not available to suggest juvenile emigration is delayed below the barrier weir. Further, transmission of IHNV from adult salmon to juvenile salmon has not been shown in Battle Creek or the upper Sacramento River despite laboratory studies and field trials (see also response to Comment 9).

Comment 12: Are eggs hardened in iodophor? The text is unclear. With the prevalence of IHNV in returning adults, iodophor disinfection during water hardening is critical.

Response: Eggs are water hardened in a 100 ppm iodophor bath for 15 minutes (Piper et al. [1982] recommend 100 ppm for 10 minutes). A solution of 50 ppm will kill virus in two minutes when not in a protein solution (S. Foott, CA-NV FHC, pers.comm.). This language has been clarified in Section 9.1 (page 9-3).

Comment 13: Using iodophor to disinfect equipment is necessary to prevent transmission of IHNV from infected adults to juveniles, but the concentration must be maintained at an effective level and equipment must be exposed for a sufficient amount of time. How is this being managed?

Response: Equipment are disinfected at approximately 500 ppm. Personnel step into a large tub, immerse boots to water line, and scrub down with a brush. Brushes are then rinsed and left near the disinfection tub. Other equipment is usually sprayed, brushed down, and rinsed. Rain gear and other equipment used in the spawning building are not used in other areas of the hatchery.

Comment 14: Describe the history of fish health and rearing in Section 9. What pathogens are of concern and what research is necessary to resolve disease epizootics?

Response: This information is presented in Section 10 (Juvenile Releases), particularly in Section 10.5. To help avoid additional repetition, we have only presented this information in one section. A sentence referring the reader to Section 10.5 has been added to the "Fish Health Maintenance and Monitoring" subsection in Section 9.2.

15.3 Broodstock congregation and the Coleman barrier weir

Comment 15: One commentor expressed concern with the use of the barrier weir to maintain spatial (they wrote temporal) separation of spring and fall chinook salmon in Battle Creek. This commentor suggested that reductions in fall chinook production may help eliminate the need to maintain physical separation.

Response: Decisions regarding future passage of fall chinook at the Coleman barrier weir will be made by the resource agencies as part of the Battle Creek restoration and adaptive management process. Current emphasis of restoration activities have concentrated on at-risk stocks of winter and spring chinook salmon and steelhead trout. Additional information is needed (e.g. spatial segregation of fall and spring chinook salmon in a restored Battle Creek) before a decision is made to allow fall chinook unrestricted passage into upper Battle Creek. Given that spring chinook salmon are currently restricted from ascending beyond the Eagle Canyon Dam on the North Fork Battle Creek and Inskip Dam on the South Fork Battle Creek, it is unlikely that fall and spring chinook salmon would segregate spatially. There is considerable risk that returning fall chinook salmon could swamp naturally spawning spring chinook if allowed access above the barrier weir. This seems likely even with substantial decreases in fall chinook production at Coleman NFH since the recent over-escapement of fall chinook salmon appears to be related to increased ocean survival and is not related to increases in hatchery production. In addition, decreases in production of fall chinook salmon at Coleman NFH would need to be evaluated in regards to the federal governments responsibilities to mitigate for habitat losses resulting from Shasta Dam.

Comment 16: It is unclear whether delayed mortality occurs from handling stress associated with broodstock collection activities or Coleman barrier weir trapping efforts. A study addressing these issues should be conducted.

Response: An investigation of delayed mortality associated with broodstock collection activities is warranted. Preliminary data, however, showed hatchery-origin winter chinook salmon trapped at the Coleman NFH barrier weir and relocated to the mainstem Sacramento River survived to spawn and were subsequently recovered in the mainstem carcass survey.

Comment 17: Impact assessments to natural populations from barrier weir operations are all directed at adults. The draft BA does not address impacts to outmigrating juvenile salmonids that must traverse the Coleman barrier weir and the large numbers of broodstock collected below it.

Response: Juvenile emigrants can pass downstream anywhere across the entire length of the Coleman barrier weir or through the adult fish ladder. Although no studies have been conducted to evaluate juvenile emigration past the Coleman barrier weir, the Service considers it unlikely that the structure impedes downstream migration of juvenile salmonids nor is it anticipated that the structure poses a direct threat of injury or mortality to downstream migrants.

Currently no data are available regarding impacts to outmigration of juvenile chinook and steelhead trout associated with large numbers of broodstock below the Coleman barrier weir.

Comment 18: What is the efficiency of the upstream ladder at all flows? Is there sufficient attraction? Is fish passage impacted or delayed at any flow? What evidence exists to indicate that migration delays do not pose a problem?

Response: Data associated with monitoring winter and spring chinook salmon at the barrier weir fish ladder from March through August show that adult salmonids do use the ladder to pass into upper Battle Creek. Additionally, the fact that adult salmonids are seldom witnessed jumping at the barrier weir when the fish ladder is open anecdotally suggests that attraction flows and passage efficiency through the ladder are adequate. However, direct data regarding the passage efficiency of the existing barrier weir fish ladder (including time required to pass) are not available. Funds have been secured from CALFED to modify the existing Coleman NFH barrier weir and adult fish ladder structures to provide increased control over passage, to provide improved monitoring capabilities, and to provide improved attraction and passage of adults.

15.4 Broodstock collection and mating

Comment 19: Intentionally avoiding using resident rainbow trout from the integrated resident-anadromous *O. mykiss* population as broodstock is a form of artificial selection and should be avoided in a conservation program.

Response: As stated in the BA, smaller-sized *O. mykiss* were previously excluded from the propagation program at Coleman NFH because they were thought to be possible remnants of a non-migratory strain. The decision to exclude smaller-sized *O. mykiss* from the Coleman NFH steelhead program was made prior to relatively recent information showing the highly variable life history strategies of the species. In response to recent information, including research conducted at Coleman NFH, the Service has begun to incorporate steelhead trout from the entire distribution of sizes as hatchery broodstock.

Comment 20: Past selective breeding leaves little doubt that the hatchery stock of steelhead trout is different from the founding population.

Response: Coleman NFH steelhead have been demonstrated to be closely aligned genetically with the remaining natural populations of steelhead (Busby et al.1996). For this reason, the Coleman NFH component of the steelhead population is considered part of the Central Valley steelhead ESU (Busby et al.1996).

The Service examined steelhead broodstock collection and spawning practices and, in 1999, reached a decision to incorporate shorter steelhead into the spawning matrix. Complete exclusion of smaller-sized *O. mykiss* from hatchery spawning was conducted for about ten years, representing approximately three generations of hatchery fish. During that time, broodstock size selection criteria undoubtedly selected against the phenotype of shorter, early maturing adults. The degree to which these selection practices has changed the genotype of steelhead trout at Coleman NFH is not known.

The following factors would tend to decrease potential genetic impacts resulting from previous broodstock selection practices:

1) Size and age at return for steelhead trout are characteristics that are not entirely controlled by genetic factors, but are also highly influenced by environmental factors, some of which are associated with hatchery propagation (e.g. high growth rate, early age at smolting). The extent to which smaller-sized steelhead have been excluded from the propagation program appears to be large, however, it is clear that environmental influences, not genetics, predisposed the majority of the smaller-sized adults to return as 2-year olds. Adult return data from Coleman NFH show that steelhead shorts (<554 mm, predominantly age-2) continue to comprise a large portion of adult spawners.

b) Egg size in steelhead trout is related to female body size; with smaller-sized steelhead trout generally producing smaller-sized eggs. Smaller-sized eggs produce smaller-sized juveniles, which may experience survival disadvantages in the wild. Although it has not been shown empirically, it is possible that naturally-producing smaller-sized steelhead trout are selected against in the wild, similar to the selection strategy previously used at the hatchery.

The Service has initiated a genetic investigation of steelhead trout from Coleman NFH and steelhead from several other locations of the upper Sacramento River system including Clear, Mill, and Deer creeks and the mainstem Sacramento River. This investigation will use microsatellite DNA to investigate genetic relationships between steelhead trout from Coleman NFH and naturally produced steelhead trout. Results of this investigation will be compared to those results previously presented in Busby et al. (1996).

Comment 21: The Service needs to ensure that incorporation of natural steelhead as hatchery broodstock does not 'mine' the natural population. The Service should establish a sampling plan similar to that developed for winter chinook (i.e., based on a relatively small proportion of the natural run).

Response: The existing population of steelhead trout in upper Battle Creek is comprised largely of fish from hatchery ancestry. As discussed in Sections 6.5 and 7.5, the Service will continue to release unspawned hatchery and natural steelhead trout above the Coleman NFH barrier weir to compensate for any natural steelhead trout used as broodstock.

A target of forty natural steelhead will be incorporated into the hatchery program on an annual basis to reduce the effects of domestication selection on the hatchery stock. The numbers of returning adults passed above the barrier weir should greatly exceed this number based on recent returns [e.g., 1,483 steelhead were passed above the barrier weir in brood year 2001 (131 were unmarked and presumed natural-origin)]. Passage of hatchery and natural steelhead will ensure that available spawning and rearing habitats are fully seeded. The Service will continue to monitor to assess any impacts caused by hatchery operations, and programs will be modified, when warranted, to reduce impacts to natural stocks.

Comment 22: The practice of releasing partially spawned male steelhead is interesting. However, unless there is a shortage of males, this practice could lead to over-representation of genetic variation present in these individuals.

Response: The practice of releasing partially spawned male steelhead will be re-evaluated in regards to the genetic concerns stated in this comment.

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Comment 23: Is a portion of the entire run of steelhead trout retained at Coleman NFH as potential broodstock? How are steelhead chosen for passage above the barrier weir? It is unclear from the discussion presented in Section 7.3 (subsection on steelhead trout).

Response: Steelhead adults are managed in the hatchery's adult holding ponds so that hatchery broodstock are representative of the entire duration of run and spawn timing.

Comment 24: Given that 90% of the returning population is hatchery-origin, is the number of winter chinook broodstock large enough to minimize divergence between hatchery and natural populations?

Response: This is a misunderstanding. Ninety percent of the fall chinook salmon returning to Battle Creek are thought to be hatchery-origin. The percent of hatchery-origin winter chinook returning to the upper Sacramento River will be variable (see USFWS 1993). The number of hatchery-origin winter chinook salmon adults collected as broodstock is limited to 10%, so 90% of the hatchery's broodstock of winter chinook are natural-origin.

The current number of broodstock (approximately 15% of the winter chinook run size estimate, or, minimum of 20 and a maximum of 120 adults) was developed in an effort to balance the risks of 'mining' the already endangered natural population with the need to maintain genetic diversity among the hatchery propagated population. A maximum of 120 can only be collected due to facility limitations. The derivation of the minimum and maximum number of winter chinook to be used as broodstock has been described in detail in previous documents (see USFWS 1993 and USFWS 1996a).

Comment 25: Is it possible to modify the operation of the Red Bluff Diversion Dam to allow collection of winter chinook salmon across the range of their run timing?

Response: Collection of winter chinook broodstock at RBDD across the entire distribution of run timing is possible, but would require the dam gates to be in place during the entire migration season (December through August). Changing operations of RBDD to allow increased collection opportunities for winter chinook would increase impacts to fish populations in the upper Sacramento River system, including ESA-listed winter and spring chinook salmon.

Comment 26: Unmarked chinook salmon genetically identified as non-winter run are relocated to the same location as winter chinook. Does this create a risk to the winter population?

Response: Unmarked non-winter chinook collected during winter chinook broodstock collection activities are likely late-fall chinook (at the beginning of the run) or spring chinook (at the end of the run). All three runs potentially commingle in the upper Sacramento River at that time but may segregate themselves reproductively either spatially, temporally, or behaviorally (e.g., spawn timing for winter chinook typically does not greatly overlap with either of these runs; [Vogel and Marine 1991]). The intent of releasing non-winter adults is to allow them to contribute to natural reproduction. It is not the intent of the program, nor is it likely, to manipulate spawning distributions of these runs by relocating them to other areas.

Comment 27: The number of natural fall chinook salmon spawned as broodstock should be increased to help ameliorate the effects of large hatchery to natural ratios of returning adults.

Response: Due to low marking rates, it is not currently possible to distinguish all hatchery fall chinook salmon from natural fall chinook. Therefore, it is not possible to select natural fall chinook as broodstock on a fish-by-fish basis. The Service is currently considering several changes to current operating procedures at Coleman NFH including increasing the number of adults spawned and culling excess eggs (see Section 8.6). This would increase the number of natural fall chinook (although not necessarily the proportion of natural fall chinook) used as broodstock. The Service is also examining the feasibility of marking a larger proportion of hatchery fall chinook (up to 100%) to help distinguish between hatchery and natural populations of fall chinook salmon in Battle Creek. This may allow a higher proportion of natural fall chinook adults to be incorporated as broodstock in the future.

Comment 28: How were phenotypic criteria for culling determined? Is there any scientific literature to support this selection process?

Response: Fish culled are generally randomly selected from available adults that are in excess of broodstock requirements. Phenotypic criteria are generally not used to determine which fish will be culled.

Comment 29: One commentor also questioned the necessity of culling adults whose run timing increases overlap between fall and late-fall chinook salmon.

Response: Any behavioral or spatial isolation elements that may minimize hybridization between stocks in the natural environment are removed in artificial propagation programs since salmon are not allowed to chose mates. To promote separation in spawn timing and minimize the potential for hybridization between late-arriving fall chinook and early-arriving late-fall chinook, chinook salmon adults returning between fall and late-fall spawning have been culled at Coleman NFH.

Comment 30: Rather than culling excess adults, would it be possible to spawn all or most of the returning adults and cull representative subsamples of eggs.

Response: The Service is currently considering increasing the number of adults incorporated as broodstock (for all stocks except winter chinook) and culling excess eggs. Incorporation of this operational change at Coleman NFH would help to maintain genetic variability within the hatchery stock, and greatly increase the effective size (N_e) of the hatchery population. The Service hopes to begin implementing this strategy by fall spawning 2002.

Comment 31: Rather than using phenotypic criteria to distinguish between fall and late-fall chinook, would it be possible to collect adults from areas where they are expected to spawn, or do the distributions overlap too much to make this proposal feasible?

Response: Spawning distributions of fall and late-fall chinook salmon overlap both in Battle Creek and in the upper Sacramento River, the primary spawning location for late-fall chinook. In collecting adults at either location, phenotypic criteria would need to be used to separate hatchery broodstock, especially when fall spawning overlaps with late-fall spawning.

Comment 32: Broodstock selection strategies are discussed in Section 6.5 for incorporating natural-origin adults as broodstock, but no information is provided on how these strategies were derived or how these spawners were going to be collected (e.g., across the range of run timing). What is the impact to the natural population from removing 135 adults, and what is the collection strategy (i.e., a few fish over the range of run/spawn timing)?

Response: While many researchers agree that including natural-origin adults as broodstock is important to minimize divergence between hatchery and natural populations and therefore genetic risks, the rate of incorporation is not known. From an ideal genetic perspective of minimizing all effects of domestication selection, all of hatchery broodstock would be natural-origin adults. The rates of incorporation specified in Section 6.5 (10% every year for fall chinook salmon and steelhead trout and 25% every generation for late-fall chinook salmon) reflect a best effort to balance risks of removing natural adults from naturally spawning populations with the importance of minimizing divergence between natural and hatchery populations. Explanations of the reasoning behind the 10% and 25% incorporation of naturals has been included in the relevant subsections of Section 6.5. Natural-origin chinook will be collected and incorporated as broodstock across the range of run (and spawn) timing.

Comment 33: The Service reports low prespawning mortality, but does not report actual estimates of prespawning mortality.

Response: Estimates of prespawning mortality prior to first sorting are available for fall chinook salmon and steelhead trout and have been included in Section 7.3. Similar data are not available for late-fall chinook salmon since these adults are frequently held for longer periods of time after initial sorting as compared to fall chinook salmon, and they are not separated in the same manner as steelhead that are held. An estimate of pre-spawning mortality has been included for late-fall chinook salmon in Section 7.3.

Comment 34: The BA should discuss strays from other hatcheries and impacts on Coleman NFH broodstock (i.e., risks of incorporating strays from other hatcheries as broodstock).

Response: The rate of straying and the geographical distribution of straying adults from other Central Valley hatcheries is likely increased for hatchery facilities that conduct large off-site releases. Strays from other hatcheries are collected and occasionally spawned at Coleman NFH. For example, in some years up to six coded-wire tagged fall chinook salmon from other facilities were recovered at Coleman NFH (Service, unpublished data; Pacific States Marine Fisheries Commission website). Assuming a mark rate of < 8% at the other hatchery facilities, these fish could represent approximately 70 strays from other hatcheries returning to Coleman NFH. Although collection and spawning of strays at Coleman NFH is not a desirable outcome, it is not likely that this number of strays has resulted in significant genetic impacts to stocks at Coleman NFH. Minimal genetic impacts are expected because the number of strays spawned at Coleman NFH is very small in relation to the number of true-homing fish that are spawned For example, although six coded-wire tagged strays were recovered, some or all of them could have been excessed rather than actually included in the spawning population. Additional analysis needs to be conducted to determine the exact disposition of the strays from the other hatcheries.

In contrast, the potential impacts to less abundant natural spawning populations at different locations of the Central Valley could be more severe, as strays from other hatcheries undoubtedly spawn naturally throughout the Central Valley system.

Comment 35: Why are chinook salmon less than 650 mm FL not used as broodstock?

Response: Chinook salmon jacks (<650 mm) are incorporated as hatchery broodstock at a rate of approximately 5%.

Comment 36: Are drugs or therapeutic agents used on adults at Coleman NFH?

Response: No drugs or therapeutic agents are used to treat broodstock at Coleman NFH.

15.5 (Over) Escapement and carrying capacity of Battle Creek

Comment 37: High densities of adult fall chinook may have positive (increased food/nutrients) or negative (decreased oxygen, increased concentrations of pathogens) effects on restored populations (e.g., steelhead) if juveniles move downstream and rear in lower Battle Creek. Are data available from Mill or Deer creeks to suggest if lower Battle Creek serves as important rearing habitat?

Response: The time-frame in question here is about October through December. During this time of year, fall chinook carcasses can be prevalent in Battle Creek prior to decomposition or being washed downstream by high-flow events. The Service has conducted research to examine possible negative effects to juveniles caused by reduced dissolved oxygen concentration and disease transmission, and found no evidence to suggest negative impacts. Furthermore, we are unaware of any data to show that Mill or Deer creeks provide important rearing habitats during

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that time of year, and we have concerns about the relevancy of that information in regards to predicting the importance of rearing habitats in Battle Creek.

Comment 38: Increased discussion of density-dependence and levels of production at lower escapements may be warranted.

Response: Information from additional years of adult escapement and resultant juvenile production will be analyzed as it becomes available.

Comment 39: One of the performance standards mentioned in Sections 1.9 and 1.10 is that Coleman NFH production will not exceed the carrying capacity of freshwater, estuarine, or ocean environments. The listed fish culture practice concerns only juvenile releases. In recent years, significant over-escapement of fall chinook adults has occurred. The draft BA should address the possibility of adult returns exceeding the carrying capacity of Battle Creek.

Response: As mentioned in Section 2.10, the only available estimate of Battle Creek carrying capacity (5,000 adults) is apparently low. Even so, there is no doubt that the carrying capacity of Battle Creek has been exceeded in recent years (although, see Section 2.10). The Service has culled large numbers of returning fall chinook salmon to partially alleviate this problem of high hatchery returns. In addition, the Service will continue to investigate concerns associated with over-escapement of fall chinook adults, and will consider culling additional fall chinook adults to minimize potential negative impacts to natural populations (see Section 3.7 and Appendix 3D for a discussion of over-escapement to Battle Creek, see Section 8.6 for a brief discussion of proposed increases in culling). The hatchery's practice of culling large numbers of fall chinook adults has been added to the 'Relevant fish culture practices' subheading in Section 1.10, performance standard R4.

Comment 40: Data presented in the draft BA indicate that previous estimates of Battle Creek's adult carrying capacity are likely incorrect. Given this, the practice of excessing surplus adults to alleviate chinook salmon biomass seems unwarranted. A study should be conducted to re-evaluate estimates of carrying capacity for Battle Creek.

Response: The fall chinook salmon propagation program at Coleman NFH is based on mitigation responsibilities, and natural spawning by hatchery fish is not an intended outcome of the program. Estimates of carrying capacity in Battle Creek were formulated in regards to a natural population of fall chinook salmon, sustainable without large infusions of hatchery-origin adults. The spawning conditions witnessed in Battle Creek during recent years of hatchery over-escapement are not natural, nor are the large juvenile production estimates resulting from those spawning events. Information from additional years of adult escapement and resultant juvenile production will be analyzed as it becomes available

Comment 41: Could a substantial portion of the unmarked fall chinook salmon spawning in lower Battle Creek be a result of obstruction by the barrier weir rather than 'decoying' of naturally-produced salmon?

Response: Fall chinook salmon are generally confined to below the Coleman NFH barrier weir in Battle Creek. Relatively few fall chinook salmon escape above the Coleman barrier weir to spawn naturally. Recent increases in fall chinook escapement to Battle Creek have occurred without significant changes in the structure of the Coleman barrier weir, and operational changes have only increased upstream passage.

15.6 Effects (aside from disease) of juvenile releases

Comment 42: There is no discussion of the number of naturally-spawned juvenile salmon (or trout) rearing in the lower five miles of Battle Creek when hatchery fish are released. Almost certainly the tremendous numbers of hatchery juveniles released from Coleman NFH would have deleterious effects on naturally rearing juveniles, but the overall effect would depend on the number of naturally spawned fish present.

Response: Hatchery releases are timed to coincide with smoltification of hatchery fish and favorable outmigration conditions. Juvenile monitoring shows that hatchery fish emigrate quickly after release from Coleman NFH (See Section 10). Naturally-produced salmonids are also likely outmigrating or redistributing rather than rearing during those time periods. Juvenile fish monitoring at the Red Bluff Diversion Dam showed that natural-origin fall chinook salmon generally emigrate soon after emergence and are not likely to be prevalent in Battle Creek when the largest releases are conducted at Coleman NFH (April release of 12 million fall chinook salmon). Additional information will be gathered when the Service re-initiates a juvenile monitoring program using rotary screw traps Battle Creek.

Comment 43: Is instream final acclimation and volitional release practiced? If not, is this alternative being considered? Would this help alleviate concerns of predation and competition/displacement?

Response: Because Coleman NFH is located in the Battle Creek watershed, the location where most hatchery releases occur, and Coleman NFH obtains it's water directly from the creek, acclimation to receiving waters is not necessary. The volitional release strategy would be considered, however, the design of the hatchery raceways do not facilitate that release strategy.

Comment 44: A good discussion of impacts of juvenile releases is presented in Sections 10.6 through 10.12. However, a summary of impacts associated with releases of hatchery juveniles on naturally-produced juvenile salmonids would be useful. Areas for future research should be identified (e.g., long-term disease transmission and mortality studies), and mitigation strategies for low and moderate impacts need to be developed.

Response: Tables 10-11, 10-13, 10-15, and 10-16 (Section 10.9) provide summaries of impacts resulting from releases of fall, late-fall, and winter chinook salmon, and steelhead trout, respectively.

Future research will continue to monitor the hatchery's success in meeting performance standards and further minimize impacts.

Comment 45: In Section 10.8, the discussion of predation impacts of fall chinook salmon are classified as 'none' in Table 10-11, but are described as 'minimal' in the text. These need to be clarified to be consistent. If impact is low, how is it being mitigated?

Response: Wording of the text has been modified to clarify apparent inconsistencies. The assessment of "minimal" impacts referred in the text was intended to relate to the number of anticipated occurrences of predation by hatchery-origin fall chinook. The impact of "none" referred to in Table 10-11 is an assessment of the severity of impact to natural populations resulting from predation by hatchery-origin fall chinook, at the scale of both Battle Creek and the ESU.

Comment 46: In section 10.8, benefits to natural salmonids outmigrating with hatchery fall chinook salmon are discussed, but possible risks are not presented. Is there no risk of competition or displacement of natural juveniles from large numbers of hatchery fish in the migratory corridor?

Response: Competition and displacement as described in Section 10, typically occur when individuals or groups of individuals are competing for rearing space or other limited resources. Rearing juveniles and outmigrating juveniles are typically spatially separated. For example outmigrating juveniles remain in the thalwag, while rearing juveniles select bottom and near shore habitats. The strategy used to minimize the impact of competition and displacement is to assure released juveniles are ready to actively outmigrate, thus avoiding impacts on those juveniles still residing in the system.

Comment 47: Present data to substantiate emigration rates and better depict hatchery release timing and natural juvenile emigration in Section 10.8.

Response: Emigration rates for hatchery chinook are presented and discussed in Section 10.1. A sentence has been added to Section 10.8. referring the reader to Section 10.1 for a more complete discussion of emigration rates for hatchery juveniles. Additionally, Appendix 10D has been added showing the temporal patterns of emigrations of natural juvenile salmonids in Battle Creek.

15.7 Spring chinook issues

Comment 48: Coleman NFH was constructed to mitigate for salmonid habitats lost by the construction of Shasta Dam, including spring chinook salmon habitat. The BA does not mention mitigation for lost spring chinook habitat. Section 6.1 should include any information on past or proposed efforts to propagate spring chinook salmon at Coleman NFH.

Response: Discussions of past propagation efforts for spring chinook salmon have been included in Section 1.2, and Appendices 1A (history), 6A (broodstock collection), and 10A (juvenile releases). This information was not included in Section 6.1 because this section concerns only current propagation programs.

Comment 49: The draft BA does not address spring chinook in Battle Creek.

Response: Potential impacts to natural spring chinook salmon have been considered in relevant assessments and discussions of impacts resulting from hatchery facilities and operations, including hatchery water source and facilities (Sections 4 & 5), broodstock collection and identification (Section 7), and juvenile releases (Section 10).

Comment 50: Please clarify why spring chinook salmon are not included in any performance indicators (Section1) or in the Monitoring and Evaluation Section (Section 11). A mitigation responsibility of the Service at Coleman NFH should be for spring chinook salmon. What is being done to address this?

Response: The Performance Indicators (Section 1) and the associated Monitoring and Evaluation activities (Section 11) pertain directly to fish stocks that are propagated at Coleman and Livingston Stone NFH's (e.g., fall, late-fall, and winter chinook salmon and steelhead trout). Because spring chinook are not currently propagated at Coleman or Livingston Stone NFH's, they are not identified in association with any of the performance indicators.

Although spring chinook are not directly listed in association with any Performance Indicators or their Monitoring and Evaluation activities, natural-origin spring chinook salmon are thoroughly considered within the Service's Monitoring and Evaluation activities. For example, within the Performance Indicators assessing risks, all six of the Performance Standards, and the associated Monitoring and Evaluation activities, pertain in-part to spring chinook salmon as that stock is potentially affected by hatchery programs at Coleman and Livingston Stone NFH's.

The possibility of initiating a propagation program for spring chinook salmon is under consideration through the Coleman NFH Re-evaluation Process. If decisions are made to initiate spring chinook salmon propagation programs as part of the Coleman or Livingston Stone NFH operations, appropriate performance indicators will be added.

Comment 51: It is possible that high return rates for fall chinook salmon to Battle Creek could negatively affect spring chinook salmon in this tributary. Perhaps production of fall chinook salmon at Coleman NFH should be decreased.

Response: While it is possible that large returns of fall chinook salmon to Coleman NFH could affect spring chinook salmon in Battle Creek, our assessment of impacts does not necessarily suggest that a decrease of fall chinook production would substantially lessen any impact. For example, the most apparent impact of fall chinook salmon on natural spring chinook salmon in Battle Creek occurs during the period of fall chinook broodstock congregation and collection. Broodstock congregation and collection for fall chinook salmon extends from September 1 through the end of the spawning season in mid-November. During that time period, nearly all spring chinook salmon in Battle Creek should have migrated into the upper reaches of the watershed, above the Coleman barrier weir. Late-arriving spring chinook salmon could be blocked, however, from ascending Battle Creek by the Coleman barrier weir. Blockage of these fish would occur regardless of fall chinook production levels at Coleman NFH because all fall chinook are restricted from ascending above the Coleman barrier weir.

Currently, the Coleman barrier weir is operated to minimize the risk to spring chinook of being 'swamped' by returning fall chinook. However, the current structure does allow some unregulated passage during high flows. Funds have been secured from CALFED to modify the existing Coleman NFH barrier weir and adult fish ladder structures to provide increased control over passage (barrier weir), to provide improved monitoring capabilities (fish ladder), and to provide improved attraction and passage of adults (fish ladder).

Comment 52: Fall chinook salmon should be excluded from upper Battle Creek at least until the spring chinook population is re-established.

Response: Current broodstock management practices at Coleman NFH do attempt to completely restrict passage of fall chinook salmon above the Coleman barrier weir, however, some fall chinook salmon are able to escape above the barrier weir. Fall chinook are blocked from upper Battle Creek to prevent hybridization and swamping of natural spring chinook salmon. A decision to allow intentional passage of fall chinook salmon into the upper Battle Creek watershed would need to be accompanied by an assessment of risks, showing that this action would not pose substantial risks to naturally producing spring chinook salmon. Funds have been secured from CALFED to modify the existing Coleman NFH barrier weir and adult fish ladder structures to provide increased control over passage (i.e., prevent unregulated passage above the barrier weir), to provide improved monitoring capabilities, and to provide improved attraction and passage of adults at the fish ladder.

Comment 53: Sections 2.6 and 2.7 need to discuss direct and incidental effects to ESA-listed spring chinook salmon.

Response: Spring chinook salmon are not currently propagated at either Coleman or Livingston Stone NFH's, so there will be no direct effects of hatchery propagation on the species. Spring chinook salmon are identified in Section 2.7 as an ESA-listed population that may be incidentally affected by the species. An assessment of indirect effects are identified and discussed in Sections 2.11 (summary), 4.3 and 4.4 (take from hatchery water withdrawals), 7.9 (risks from broodstock collection), 7.11 (estimated take from broodstock collection), and Sections 10.5 through 10.12 (risks associated with releases of hatchery juveniles).

15.8 Coleman NFH and Battle Creek restoration efforts

Comment 54: The draft BA states that artificial propagation programs at Coleman and Livingston Stone NFH's are managed to align with CVPIA and CALFED restoration efforts, but does not mention the goals and objectives of the CALFED ERP or articulate the goals of the AFRP (CVPIA). A discussion of how current and future operational changes from CVPIA and CALFED funding will impact overall Battle Creek restoration is warranted.

Response: A more complete description of AFRP goals, ERP goals, and the Coleman NFH Re-evaluation process, and the integration Coleman NFH with each of these programs has been added to Section 3.3.

Comment 55: The draft BA does not appear to justify suggested operational alternatives or describe whether these alternatives are compatible or synergistic with CALFED and CVPIA restoration goals. Performance standards should stipulate what these goals are.

Response: Operations of the Coleman and Livingston Stone NFH's need to stay in alignment with CALFED and CVPIA goals. The relationship of those programs and Coleman NFH is presented in Section 3.3.

15.9 Estimated impacts, take estimates, and mitigation efforts

Comment 56: The Service should address impacts associated with unscreened hatchery water diversions and quantify take at these diversions.

Response: Estimates of take occurring at each of Coleman NFH's three intakes is presented in Section 4.3 and 4.4, and Appendix 4A. A summary of numeric take estimates for water intakes and broodstock collection is located in Section 2.11.

Comment 57: Can any actions be taken to reduce take levels associated with hatchery water withdrawals? If not, how is this take being mitigated?

Response: Existing water intake structures at Coleman NFH do not adequately protect natural stocks in Battle Creek. These structures will be redesigned and restructured to meet NMFS screening criteria. Salvage operations are in place to help remove entrained fish from the hatchery's water diversions. A description of salvage activities is presented in Section 4.1.

Comment 58: Shifts in number and timing of juvenile emigration have been observed in other tributaries under different water conditions. Have these possible shifts been factored into take estimates?

Response: The estimates of take associated with water diversions at Coleman NFH are based on *anticipated* emigration timing and life-stage. Anticipated timing and life-stage at emigration is based upon emigration patterns observed in Battle Creek and the upper Sacramento River and knowledge of the general emigration (life history) strategy of each species. The Service is aware that emigration patterns can differ, often substantially, from year to year; however, the process of estimating take based on every possible permutation would be very difficult and would provide information of limited value.

Comment 59: A general discussion on occurring or proposed measures to reduce or eliminate impacts identified in the draft BA is warranted.

Response: Discussions of actions taken to ameliorate impacts are located within pertinent sections of the BA (e.g., changes to release times/locations, efforts to screen Coleman NFH water diversions, salvage efforts etc.).

Comment 60: Effects of hatchery water withdrawals on the 1.2 to 1.6 mile stretch of Battle Creek that is affected by the water withdrawals are not discussed. What are the impacts to spawning and rearing habitat or the migratory corridor?

Response: The Service incorporated Section 4.5 to address impacts to salmonid habitat from hatchery water withdrawals. This section discusses effects during normal water years and operations, possible emergency situations, and drought years.

Comment 61: What were the sources for fecundity estimates in Section 4.3 used to generate estimates of juvenile take? No sources are provided and estimates for spring chinook salmon do not agree with current literature.

Response: Current estimates for fecundity of spring chinook salmon have been incorporated into Section 4.3, and corresponding changes in estimated take for spring chinook juveniles are shown in Section 4.4. Fecundity estimates for all other stocks are based on ten year averages from hatchery records and have been referenced as such in the document.

Comment 62: Readers need estimates of error in order to assess reliability of parameter estimates.

Response: Wherever possible, we have included confidence intervals on estimated parameters.

15.10 Issues associated with marking efforts

Comment 63: Natural returns of fall chinook salmon may be overestimated because the Service does not account for decreased survival of CWT'd fish.

Response: Coded-wire tagged fish are generally held for a minimum of 21-days after the tagging process to estimate tag loss and mark retention. During that time, mortality of tagged fish is also enumerated and subtracted from the reported release numbers. Based on information generated through this process, differential mortality of coded-wire tagged fish generally occurs within a 10-day window following tagging, or not at all. Although it is possible that some delayed mortality does occur, we believe that the number of delayed mortalities occurring as a result of tagging would be very small, and not measurable in regards to estimating adult returns.

Comment 64: Unless the hatchery fish are marked in some way, Coleman NFH cannot assure controlled passage. Marking is the only way to ensure only natural fish are released above the barrier weir, and would allow many statements made in the draft BA to be tested. Furthermore, marking is the only way to assure that only native stocks are used as broodstock

Response: Currently, all hatchery late-fall chinook salmon and steelhead trout are marked by clipping their adipose fin, and they can be positively differentiated from natural late-fall chinook salmon and steelhead trout accordingly. A portion of fall chinook salmon at Coleman NFH are marked (8 - 15%), so positive differentiation between natural fall chinook salmon and hatchery fall chinook salmon is not always possible. Few fall chinook salmon are expected to ascend Battle Creek, however, during times when passage is afforded to unmarked chinook salmon (January-August). In addition, marking all hatchery-origin fall chinook would not necessarily mean no hatchery-origin fall chinook would pass above the Coleman barrier weir. Under current operations, some early-arriving hatchery-origin fall chinook would be allowed passage into upper Battle Creek during August when fish passage at the Coleman barrier weir is monitored using underwater videography.

Marking a larger proportion of fall chinook salmon would likely improve our ability to identify hatchery fish, improve our interpretation of monitoring data, and provide a clearer picture in regards to abundance of natural-origin chinook salmon in Battle Creek. Working toward this end, the Service intends to pursue funding options to increase the number of fall chinook salmon marked at Coleman NFH.

Comment 65: If all hatchery fish were marked, it would be possible to tell if hatchery-origin fish returning to Battle Creek are responsible for attracting (i.e., decoying) natural fish from the mainstem Sacramento River into lower Battle Creek.

Response: Our analysis has not revealed any indication of decoying into Battle Creek (see Section 2.10 and Appendix 2A for a discussion of possible decoying into Battle

Creek). Marking all hatchery-origin juveniles would allow better discrimination between hatchery and natural populations, especially in Battle Creek. However, it is unlikely that even a 100% mark rate would allow a more accurate assessment of decoying than that already presented in the document. This is so, because unmarked fish returning to Battle Creek could be offspring of naturally spawning salmon in Battle Creek or the upper Sacramento River system. We would have no way to distinguish between the locality of origin of the naturally produced salmon. I changed the order here–moved the last sentence to the top.

15.11 Data analysis

Comment 66: Analysis used in Appendix 2A should be revised for the following reasons:

a) estimates of errors should be provided for reported total quantities of delta strays;

b) it is unclear if the method of expanding to total quantity of delta strays is appropriate;

c) one-tailed hypothesis test may not be appropriate;

d) the assumption of independence was likely violated for observations made over a series of consecutive years; and,

e) the power of the test was undoubtedly low, and should have been reported. A decision on the presence or absence of "decoying" should be deferred until the analysis has been improved.

Response:

a) estimates of errors should be provided for reported total quantities of delta strays

Mark/tag recovery information for Coleman NFH are generated through bio-sampling and represent a complete population census. Therefore, there is no probability for data-expansion error in estimates of delta-strays returning to Coleman NFH. Estimates of total numbers of delta strays spawning naturally in Clear Creek and lower Battle Creek are generated through actual tag recovery data from CDFG carcass surveys, which are then expanded to account for variable sampling effort and effectiveness. To generate estimates of total quantities of delta-strays, data for all carcass surveys conducted at each stream and within a spawning season are combined, and the total quantity of delta-strays are enumerated. Total numbers of delta-strays are calculated by direct expansion, based on the sampled proportion of the total adult abundance. Potential sources of error in the estimates of total number of delta-strays spawning naturally in Clear and Battle Creeks are largely related to statistical inferences regarding large populations that are generated through sampling a subset of that population. However, estimates of error (i.e., standard error or confidence bounds) cannot be readily calculated around these total annual population estimates because an estimate of within years variance is not available. It would be possible to calculate an estimate of error for an estimated total or average number of delta-strays over *all* years analyzed, however, such an estimate would not provide meaningful insight for purpose of this decoy analysis.

A second type of error that may have occurred in our sampling strategy results from "chance" events occurring during an experiment (e.g., a missed adipose fin-clip on the carcass survey, a lost tag during the tag recovery process, an error occurring while recording or transcribing data). Hurlbert (1984) coined the term "nondemonic intrusion" for these types of randomly occurring error-producing events. Nondemonic intrusion, which is possible in all experiments, acts by adding "noise" to the data which can act to reduce statistical power. However, the effects of these chance events, by their very nature, are generally unpredictable and unquantifiable.

b) is the method of expanding to total quantity of delta strays appropriate?

Expansion of field sample counts of delta strays to the total estimated quantity of delta strays returning to Clear and lower Battle Creeks is based on: 1) specific sampling strategies employed for carcass surveys in each stream; and, 2) logical expansions of field data to account for sampling effort. The method of "expanding" from actual tag recovery data to total estimated quantities of delta-strays returning to Clear and lower Battle Creeks was chosen to minimize the possibility of introducing systematic error (bias) that could result in type-II error (i.e., not rejecting the null hypothesis when it is in fact false). For example, because of the large number of salmon carcasses observed by survey crews in lower Battle Creek, recovery of marks/tags in that stream tend to occur at a lower rate as compared to Clear Creek (i.e., too many marked fish are encountered to collect all the heads from marked fish for tag recovery). As a result, tag recovery data (including recovery of delta-strays) from the lower Battle Creek carcass surveys are believed to be relatively less-complete, as compared to Clear Creek, resulting in larger expansion factors to extrapolate sample results to the entire population. However, the actual effects of this sampling strategy on the expansion of tag recovery data to the estimated total quantities of delta-strays in Battle Creek is unknown. In order to account for this uncertainty caused by somewhat different sampling methods between streams, raw tag recovery data in Battle Creek has been expanded using each of two different methodologies: 1) similar to Clear Creek, tag recovery data from carcass surveys in lower Battle Creek has been expanded by the inverse of the sampled fraction to account for the expected number of tags in the unsampled portion; and, 2) tag recovery data from Coleman National Fish Hatchery (complete census) has been expanded by the inverse of the fraction of fish spawning naturally below the Coleman barrier weir. The largest of these estimates of delta-strays returning to lower Battle Creek was used in the analysis. Although this expansion methodology is overtly biased in favor of showing that a higher number of delta-strays returned to Battle Creek, we wanted to provide a "worse-case" picture in regards to portraying evidence of decoying natural-origin fish into Battle Creek. Nonetheless, even after examining a worse-case expansion of available data, the number of estimated number of delta strays in Clear Creek exceeded the estimated number in Battle Creek for three of the six years of investigation.

c) is a one-tailed hypothesis test appropriate?

A one-tailed hypothesis test was determined *apriori* to reflect the question of interest about the population (delta-strays returning to the upper Sacramento River system). For the present investigation, the question of interest is whether delta-strays, as surrogates for naturally produced salmon originating from the upper Sacramento River, show an increased tendency for returning to Battle Creek as compared to Clear Creek. The mechanism by which naturally produced salmon could speculatively be lured into Battle Creek results from attraction caused by pheromones and spawning activity caused by large congregations of hatchery-origin adults. We are not aware that concern exists regarding decoying of natural-origin salmon into Clear Creek, nor are we familiar with any mechanism that would cause this situation to occur. Therefore, because our interest is whether there is a population difference in a *specified direction*, a one-tailed hypothesis test is warranted in this analysis. Additionally, a one-tailed hypothesis test provides an additional benefit of providing substantially greater power (ability to detect an actual difference) as compared to a two-tailed test.

d) the assumption of independence was likely violated for observations made over a series of consecutive years

The variable of interest in the Wilcoxan paired-sample test is the *difference* between the delta-stray measurements between Clear and Battle Creeks, matched on the basis of year of spawning (sample year). One of the assumptions necessary for the Wilcoxan paired-sample test to be valid is that population *differences* are independent (i.e., the difference between the number of delta-strays returning to Clear and Battle Creeks annually). A gross violation of independence may result in type-I or type-II statistical error, possibly leading to erroneous study conclusions. In this study, for example, the assumption of independence would be likely violated, and the choice of the Wilcoxan paired-sample test may be inappropriate, if some groups[1] of delta-strays showed an increased propensity (relative to other tagged groups) to stray into either Clear Creek or Battle Creek, and these tagged groups were sampled in the tributaries during multiple, consecutive years. If this situation occurred, it is possible that a few groups of delta-strays that showed an increased tendency to return to either Battle Creek or Clear Creek could bias the results of the analysis (as a result of non-independence between years) leading to erroneous conclusions for the investigation.

However, in contrast to the aforementioned scenario, the present analysis did not reveal a violation of independence between years. In fact, a statistical test for independence was not warranted because none of the observed tag codes were recovered during multiple years or in both tributaries. In all years examined, the occurrence of a novel tag code in either Battle Creek or Clear Creek was a unique event. This occurrence provides strong evidence for independence (random assignment) between delta-stray groups over the six years of investigation. This occurrence also suggests that the spawning destinations of delta-strays are unpredictable, especially in regards to the "chance" geographic distribution of non-homing, or "lost", adults spawning in northernmost tributaries to the upper Sacramento River.

e) the power of the test was undoubtedly low, and should have been reported

The power of a statistical test (Power = 1-β) refers to the probability of rejecting the null hypothesis (e.g., in this case that the median population difference equals zero) when it is in fact false and should be rejected. In the present analysis, the power of the Wilcoxan paired-sample test is low (power = 0.35 at α=0.10). Statistical power of this test is low for three primary reasons: 1) sample size is low (n = 6 years); 2) the difference between population measurements (i.e., Clear Creek minus Battle Creek) is highly variable between years ($\bar{x}_d$=4.8, s_d=12.12); and, 3) the median population difference is not large. In regard to these three primary factors that influence the power of this analysis: 1) statistical power will likely be substantially increased with increased sample size (i.e., continued years of study); 2) inter-annual variability ($\sigma^{2)}$ is estimated by s^2, and s^2 will also improve when it is estimated from a larger sample size (i.e., increased years of study); and, 3) the difference between the measured difference and the expected mean difference (Clear Creek minus Battle Creek) under the null hypothesis (H_0: $M_D \leq 0$) is small. The farther a population characteristic (in this study: the difference between the number of delta-strays returning to Clear and Battle Creek) is from that stated in the null hypothesis (in this study the null hypothesis was no difference between numbers of delta-strays returning to Clear and Battle Creeks), the greater will be the power to reject the null hypothesis. In the present investigation, the number of delta-strays returning to Clear and Battle Creeks was not substantively different. The estimated number of delta-strays returning to Clear Creek was an average of approximately 5 more than the total number returning to Battle Creek and Coleman NFH. For 3 of the 6 years of investigation, the number of delta-strays returning to Clear Creek was greater than the total number returning to Battle Creek and Coleman NFH. As a result, the statistical power of the analysis (the ability of the test to show that natural-origin fish were decoyed into Battle Creek) was, as anticipated, low.

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[1] Similarly-coded groups of fish typically represent fish reared under similar conditions and released at a similar place and time.

An alternative manner of examining the statistical power of the specific hypothesis being tested would be to examine the difference between the observed values and the values expected under the null hypothesis should the decoying theory actually hold true. For example, over the years of investigation (1995 - 2000) the estimated spawning populations in Battle Creek (Coleman NFH plus lower Battle Creek) were an average of 13.75 times larger (*s* = 4.97, range 9-23) than returns to Clear Creek. If the level of false attraction (decoying) into each tributary was similar to the size of the spawning populations in each tributary, we would expect a similar ratio (approx. 13.75:1) of decoyed delta-strays between Battle and Clear Creeks. Under this situation, a Wilcoxan paired-sample test would have provided a power of 0.85 (α=0.90). In other words, 85% of studies conducted under these circumstances would be expected to show a significant effect - leading to rejection of the null hypothesis that the population difference is zero. However, the test of significance in this investigation was not significant (P=0.42).

Summary of comments on decoy analysis:
Examination of data from the delta-stray study do not support the hypothesis of decoying in Battle Creek. Although the available data are not sufficient to provide a statistically powerful analysis, compelling evidence were generated through this examination to characterize the likelihood of existence and the magnitude of the hypothesized "decoying problem" in Battle Creek. Data analyzed, whether through cursory examination or through a statistical test of significance, do not support the theory that large numbers of natural-origin adults from the Sacramento River are lured into Battle Creek by congregations of hatchery-origin fish. Increased replication through additional years will facilitate improved analysis in the future.

Comment 67: In reference to Appendix 3A (Appendix 10C in the final BA) on straying, one should not feel confident that catch rate is not dependent upon ocean contribution rate unless it is known that errors in estimates of ocean contribution rate are small compared to errors in estimates of catch rates. If errors in estimates of ocean contribution rates are large compared to errors in estimates of catch rates, then estimates of linear slopes given in Figure 3A-1 (now Figure 10C-1) will be biased towards zero.

Response: The estimates of ocean catch rates and ocean contribution rates presented in Appendix 3A are based on recoveries of individual tag-codes, therefore, we are not able to derive estimates of error about these estimates. Although we consider that Ocean Contribution Rates and Ocean Catch Rates are indeed independent, that conclusion is not necessary for the purpose of the discussion in the straying section. The text of this section has been re-worked to avoid confusion and improve clarification.

15.12 Other comments

Comment 68: Please explain how the Performance Standards listed in Section 1.9 will help to "optimize, provide, maintain, create" etc.

Response: Also included in Section 1.9 are "Relevant Fish Culture Practices" and "Indirect Indicators and Achievements"; these sections highlight actions and achievements which attempt to maximize the benefits and minimize risks of artificial propagation programs at Coleman NFH.

Comment 69: The draft BA states that Coleman NFH was constructed to mitigate for 187 miles of spawning and rearing habitat lost from the construction of Shasta Dam, resulting in a 50% reduction in available habitat. I believe more than 187 and more than 50% of salmonid spawning and rearing habitat was lost behind Shasta Dam.

Response: It is difficult to accurately estimate the amount of salmonid habitat lost when Shasta Dam was constructed. Estimates presented in the BA are generally accepted values, but it is possible that somewhat more or less habitat was lost. Regardless, our intent was to highlight the large amount of salmonid habitat that was lost as result of construction of Shasta Dam.

Comment 70: Could fall chinook juveniles be released into Gover's Ditch and adults collected from this water way? Could late-fall chinook and steelhead trout production be moved to Livingston Stone NFH to reduce impacts to natural stocks in Battle Creek?

Response: This possibility is being analyzed as part of the Coleman NFH Re-evaluation process (see Attachment 3-3 for the scope of work). This BA is limited to describing current and near future hatchery activities and operations. Any hatchery management alternative forwarded through the Re-evaluation process (e.g., modifications to hatchery operations and facilities necessary to utilize Gover's Ditch as the hatchery's broodstock collection and release site) will be addressed in a future BA if the alternative is identified for implementation.

Comment 71: The Service should provide the reports from the studies listed in Section 1.

Response: Currently, several hatchery evaluation studies are in various stages of completion ranging from: being proposed for investigation; currently being planned; presently conducting field investigations; and, currently analyzing data. Generally, investigations associated with hatchery evaluation and monitoring require a minimum of 10-years to complete because: hatchery evaluation studies generally involve coded-wire tagging (CWT); CWT studies generally involve tagging for a minimum of three consecutive brood years; and, about four years are required to collect tagged returns from a single brood year. Results of studies conducted as part of the hatchery evaluation process will be available for distribution when completed.

Comment 72: It would be helpful if a more detailed experimental design was presented for the NATURES rearing experiment. Monitoring efforts and statistical methods that will be used to detect differences would also be helpful.

Response: A description of the study design, analysis, results, and conclusions for the NATURES rearing experiment is forthcoming in a future project completion report.

Comment 73: Include an introductory statement summarizing the purpose, format, and content of the BA.

Response: An introduction and overview has been included at the beginning of the BA to address these points.

Comment 74: A summary chapter for impact analysis, take estimates, and overall effects on natural populations should be included.

Response: Modifications to Section 2 (particularly Section 2.11) address this point.

Comment 75: Why is the propagation of winter chinook temporary while propagation of fall and late-fall chinook is considered to be permanent? Winter chinook lost most of their spawning and rearing habitat as well.

Response: Fall chinook salmon have always been the most intensively cultured stock (in terms of numbers produced) in the Sacramento River system because the life-history characteristics of fall chinook salmon (e.g., ocean-type, fall spawners, short period of freshwater residence for juveniles) best facilitate propagation in the hatchery environment. For this reason, fall chinook are generally used to support commercial and recreational fishery's, which is an ongoing objective for the Service's mitigation for Shasta Dam. Also included in the Service's mitigation responsibilities, however, are perpetuation of other salmonid runs which were negatively impacted by Shasta Dam, including winter chinook salmon. Winter chinook salmon were propagated at Coleman NFH beginning in 1989. At that time, the natural population of winter chinook was extremely depressed, and considered for listing under State and Federal ESA's. A hatchery supplementation program at Coleman NFH was developed to benefit and assist in the recovery of winter chinook.

Similar to recovery efforts for many other species, the hatchery supplementation program for winter chinook salmon was designed to terminate when a pre-determined recovery "benchmark" was achieved. The desire of a temporary supplementation program was agreed by the fishery trustee agencies. For winter chinook salmon that benchmark is population recovery, as defined in the proposed recovery plan for the species (NMFS 1997). That said, termination of the winter chinook supplementation program would not in itself preclude the Service from continuing to propagate winter chinook salmon to fulfill a mitigation responsibility for a new goal, such as enhancement. For that to happen, however, it would be necessary to have a consensus decision by the fishery trustee agencies, and to demonstrate that continued propagation of winter chinook salmon would not likely jeopardize the natural population.

END

04-8-02